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An Electrically-Operated Quarry and Plant for Production of Broken Stone at Gary, Ill.

The production of broken stone has developed into an industry of very large proportions in Chicago and the extensive territory of which that city is the material supply market, owing to the constantly increasing demand for broken stone in engineering, industrial and construction work. This growing demand is due largely to the great and rapid development in the use of concrete for a variety of purposes, partly to the great activity in all kinds of construction work in which stone is used, and partly also to the development of iron and steel manufacture in the district named, requiring large quantities of limestone for use as flux in the blast furnaces. There are extensive stone formations near Chicago, and in the district southwest of and adjacent to the city (and within the limits of Cook County) there is a limestone formation of considerable area and depth, which has been worked for many years as a source of supply of stone for various purposes.

The Dolese & Shepard Co., of Chicago, owns large quarry property in this district (at Gary, Ill.), and has recently put in operation one of the largest broken-stone plants ever built, with quarry equipment and stone crushing and screening machinery which are not only of exceptional capacity but are of exceptional interest from an engineering standpoint. The plant is specially notable in three ways: (1) for the extent and

ELECTRICALLY OPERATED QUARRY, HAULAGE SYSTEM AND STONE CRUSHING AND SCREENING PLANT, AT GARY, ILL.
Dolese & Shepard Co., Chicago; Owners.

(The blasted rock is handled by electric shovels (1) and loaded into electric dump cars (2), whose movements are electrically controlled by a man in the tower (3). The loaded cars pass up the incline (4) and discharge their contents in the crusher house (5), returning then by the incline (6) to the bottom of the quarry, passing under incline (4). From the main crusher house (5) the stone is taken by conveyors (7) to the second crusher house (8). A part then goes to the screen house (9) which surmounts four concrete storage bins. Another part is carried to the inclined conveyors (10) and delivered to the screen house (11) which surmounts ten storage bins. At (12) is the substation and air compressor house. At (13) is the car repair shop, which was the boiler house of the old steam plant (now removed). At (14) are the ruins of the old crusher and screen house, which was destroyed by fire in 1908.

character of its rock crushing and handling machinery; (2) for its electrical operation throughout, including that of loading shovels and haulage system in the quarry, and of the entire equipment of crushers, rolls, screens, and conveyors;

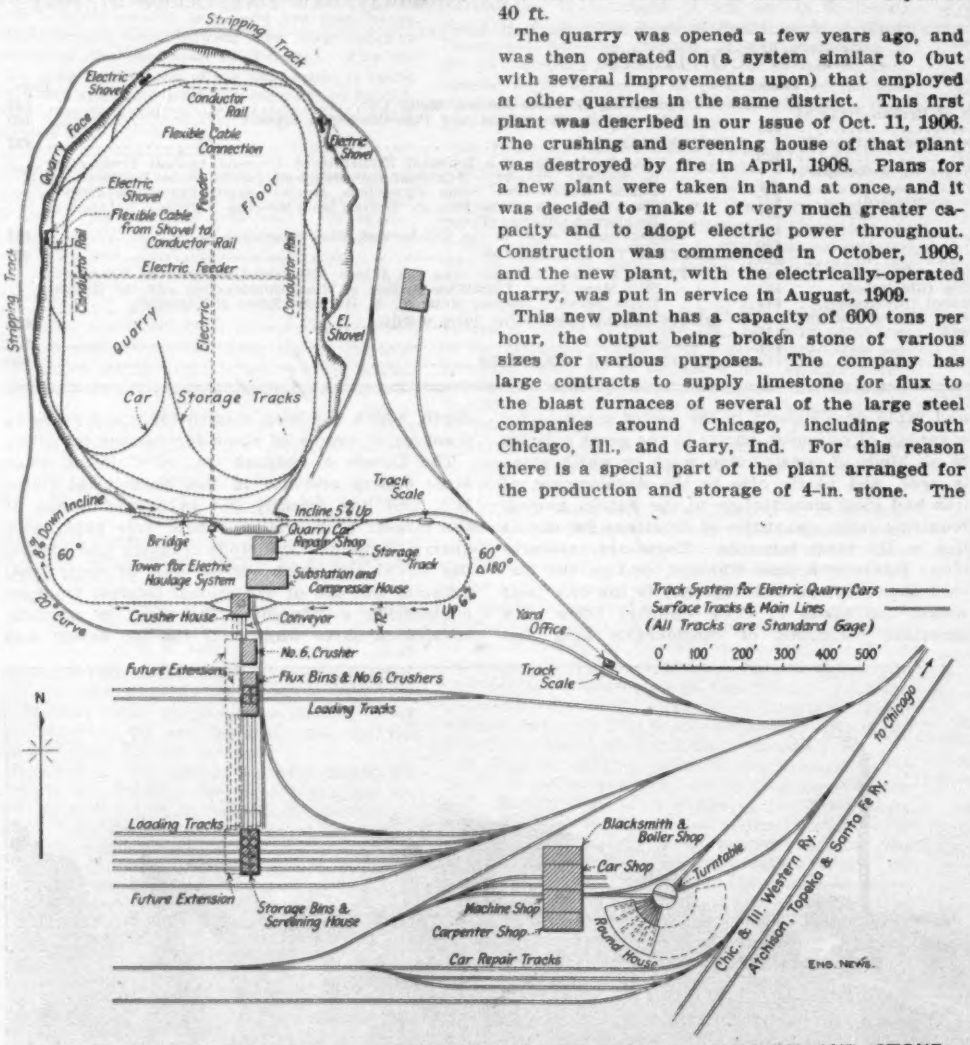

FIG. 2. PLAN OF ELECTRICALLY OPERATED QUARRY, HAULAGE SYSTEM AND STONE CRUSHING AND SCREENING PLANT AT GARY, ILL.
Dolese & Shepard Co., Chicago; Owners.

(3) for the small number of men employed and the small labor cost in relation to the large capacity of the plant. This last feature is due to the general use of electric power and mechanical operation, and reduces the labor problem to a very minor consideration. The capacity of output is about 6,000 cu. yds. per 10-hour day.

The plant is not only of interest as a whole, but presents many important and special features in all the stages of the work, from the drilling of the blast holes to the loading of the finished product into cars for shipment. Many of these features are due in a large measure to Mr. Geo. W. Patnoe, Master Mechanic and General Superintendent of the Dolese & Shepard Co., who has been in close touch with the design and construction of the plant. We are indebted to the officers of the company for plans, photographs and information furnished for the purpose of this article. The J. C. Buckbee Co., of Chicago, acted as engineers for the entire work.

The quarry and stone plant at Gary, Ill., are about 18 miles from Chicago, near the Chicago Drainage Canal and on the line of the Chicago & Illinois Western Ry. This road gives direct access to Chicago and connection (by the various belt lines) with all the railways entering that city. The company has 300 acres of land, of which 130 acres are available for stone quarrying to a depth of 250 ft., as determined by core drills. It is considered doubtful whether the quarry could be worked economically to a greater depth with present methods and appliances, but even with the special equipment and the large capacity of the new plant it will take nearly 100 years to exhaust the stone supply within these limits. There is but a very shallow covering of earth above the rock, and the stripping is done by steam shovels. The quarry as now opened has an area of about 40 acres and a depth of 40 ft.

The quarry was opened a few years ago, and was then operated on a system similar to (but with several improvements upon) that employed at other quarries in the same district. This first plant was described in our issue of Oct. 11, 1906. The crushing and screening house of that plant was destroyed by fire in April, 1908. Plans for a new plant were taken in hand at once, and it was decided to make it of very much greater capacity and to adopt electric power throughout. Construction was commenced in October, 1908, and the new plant, with the electrically-operated quarry, was put in service in August, 1909.

This new plant has a capacity of 600 tons per hour, the output being broken stone of various sizes for various purposes. The company has large contracts to supply limestone for flux to the blast furnaces of several of the large steel companies around Chicago, including South Chicago, Ill., and Gary, Ind. For this reason there is a special part of the plant arranged for the production and storage of 4-in. stone. The remainder of the plant provides for the separation and storage of various sizes of broken stone and screenings for concrete, railway ballast, street work, road making, and other purposes. It will be equipped later with washing machines, which will be used principally to produce absolutely clean stone for making concrete.

Before taking up the new system in detail, it will be of interest to describe briefly the old and new systems in general. In the old system, the loose rock broken up by blasting was loaded by hand into end-dump cars which were hauled by horses to the foot of an incline of 1.5%, up which the car was hauled by a cable. The incline led into the upper part of the crusher house and terminated by a short steep grade directly over the hopper of the main crusher. As the car ran up on this grade, the door forming the lower end was released, and the load was dumped directly between the rails into the crusher. The car was then lowered down the incline to the quarry. The old crushing and screening plant was arranged in a building parallel with the face of the quarry and having loading tracks on each side.

In the new system, the loose rock is loaded by electric shovels into side-dump cars of an electric haulage system; these pass up an incline making a turn of 180° so that the track passing through the crusher house runs parallel with the quarry. The cars are dumped by power, and pass on down another incline to the quarry, so that there is an endless loop movement instead of a shuttle movement. The row of buildings containing the crushing and screening machinery and the storage bins is at right angles to the quarry. This arrangement permits of running a number of loading tracks across or under the buildings, and gives greater capacity and greater facilities for handling and loading the railway cars.

Electric Equipment.

The operation of the entire plant will require about 2,000 HP., distributed between the quarry shovels and haulage system, the air compressors, the crushers, and the conveying and screening equipment. There is no power-house, however, but electric current is furnished by a transmission line (carrying 33,000 volts) from the water-power plant of the Economy Light & Power Co., at Joliet, Ill. To provide for emergency, this line is connected with the Fisk St. steam-operated generating plant of the Commonwealth Edison Co., in Chicago.

The current is delivered to a substation and transformer equipment which, with the main switchboard, is installed at the end of the compressor house. The main equipment of this substation includes the following: (1) three 750-KW. three-phase step-down 33,000/480-volt transformers, supplying three-phase current at 60 cycles to the motors of the machinery throughout the plant; (2) one 400-KW. and two 200-KW. Allis-Chalmers motor-generator sets producing 220-volt direct current for the electric shovels and the electric-haulage system; (3) the switchboard, controlling the distribution of current. The switchboard is so arranged that any of the motor-generator sets can be used to supply current to either the shovels or the haulage system. On the direct-current work the constant series of peaks and low points due to the intermittent heavy loads of the shovels was found to put a very severe strain on the motor-generator sets, and a storage battery has been installed therefore to take care of the peak loads. This has a capacity of 400 KW. for a few moments.

There is a complete equipment of measuring and recording instruments to indicate the power required in the different branches of the work of handling and transporting the rock, so that it will be possible to establish very accurately the requirements and cost of current for the delivery of raw material from the quarry to the crusher.

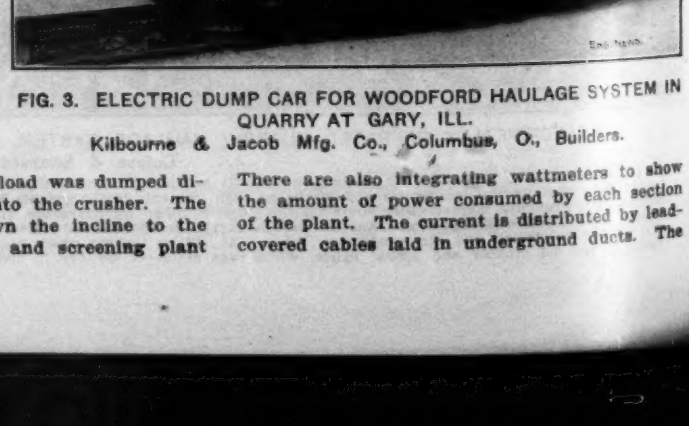

FIG. 3. ELECTRIC DUMP CAR FOR WOODFORD HAULAGE SYSTEM IN QUARRY AT GARY, ILL.
Kilbourne & Jacob Mfg. Co., Columbus, O., Builders.

There are also integrating wattmeters to show the amount of power consumed by each section of the plant. The current is distributed by lead-covered cables laid in underground ducts. The

buildings are lighted by arc and incandescent lamps, each building having a transformer to step-down the 480-volt current to the 120-volt lighting circuit. The quarry and grounds are provided with arc lamps on an independent circuit supplied with current from the substation.

In taking up a more detailed description of the work and its special features, the plant divides itself naturally into two main divisions. The first is for the supply of raw material; this includes the quarry, with its drills, loading shovels and haulage system. The second is for the preparation of the finished product; this includes the crushers, screens, rolls and conveyors; and auxiliary to this are the storage and shipping facilities. Fig. 1 (on the front page) is a general view of the quarry and buildings. Fig. 2 is a plan of the entire plant, including both of the above divisions, and showing also the repair shops of the Chicago & Illinois Western Ry.

The Quarry Plant.

The quarry is opened up in lifts of about 40 ft., and as the beds are practically horizontal it has a smooth and even floor at each lift or level. The blasting is done in vertical blast holes, 5 ins. diameter and 40 ft. deep, which are placed about 8 ft. apart.

DRILLING.—For drilling the blast holes there are two traveling frames, each mounted on four wheels and carrying four Ingersoll-Rand automatic-feed rock drills. When at work, the machine is raised and supported clear of the track by four jack screws. Each machine is equipped with a derrick for handling the long drill rods, and with a pneumatic motor for propelling it along the track. Only two men are required to attend to the four drills on each car, and this arrangement is said to reduce the labor cost 75% as compared with the ordinary methods of operating. There are also small special drills for block-holing the quarry blocks which are too large to be handled by the shovels. All the drills are operated by compressed air, furnished by two two-stage air compressors. Each compressor has a capacity of 2,200 cu. ft. of free air per minute, and is driven by a 300-HP. electric motor. The boilers of the old steam plant are used as receivers, at 80 lbs. pressure.

ELECTRIC SHOVELS.—For loading the broken rock into cars for transportation to the crusher house, there will be four very large 140-ton electric shovels, two of which are now in use. They have large shallow dippers of 4½ cu. yds. capacity (equivalent to about 6 tons of rock), and these are fitted with manganese-steel teeth. For ordinary excavation, machines of this size would have deep 6-yd. dippers. The car frame is 42 ft. long, with four 20-in. I-beam sills; it is fitted with jack arms at the front, giving a spread of 20 ft., and is supported on two steel-frame trucks. Both trucks are fitted with chain driving mechanism. The steel boom is 28 ft. long, c. to c. of sheaves. The 18-ft. dipper handle is built up of two white oak sticks 5½ × 18 ins., and is plated with steel on all sides.

The machine has a reach of about 3 ft. below and 15 ft. above the rail level. Wire rope is used instead of chains for the hoisting and swinging movements, a double line of 1-in. cable being used for each movement. The drums of the hoisting and swinging cables are 30 ins. and 34 ins. in diameter respectively, and the sheaves at the upper and lower ends of the boom are 36 ins. diameter. A cab or housing extends the full length of the car frame, and has steel sheathing and roof plating attached to steel channel posts and cross frames. A special feature is the use of power for shifting the shovel track. On each side of the machine are braces supporting a rail upon which runs a trolley hoist, by which a complete section of track may be picked up from the rear and placed ahead of the machine. A good view of one of these interesting machines is shown in Fig. 1.

Each shovel is equipped with a 200-HP. motor for hoisting, an 80-HP. motor for swinging, an 80-HP. motor for thrusting the dipper handle, and a 3-HP. motor for the air compressor used in connection with the brakes. The hoisting motor also operates the sprocket-chain propelling mechanism. Each of the three main motors has an automatic current-limit control which prevents damage or burning out of the motors in case of an overload in handling the heavy loads. With such an overload, magnetic switches introduce resistances into the motor circuit. The motors are operated by lever handles, as on a steam shovel, and there are two men to each machine. The operator in the cab controls the hoisting, swinging and propelling movements; the cranesman controls the thrusting mechanism, the motor for which is mounted on the boom. In addition there are from two to four laborers to shift the tracks, adjust the jack arms, etc. These electric shovels were built by the Vulcan Steam Shovel Co., of Toledo, O., and their electrical equipment is from the Westinghouse company.

The shovels are operated by 220-volt direct current, transmitted by copper cables from the substation to a distributing system on the floor of the quarry. This system (shown in Fig. 2) consists of lines of 70-lb. rails (with bonded joints) laid in a wooden conduit or trunk; this is in the form of a cross, with its arms in the axes of the oval quarry. From each of the three outer ends of the cross extend conductor rails approximately parallel with the face of the quarry, and the ends of these conductors are about 400 ft. apart. Each shovel has a 200-ft.

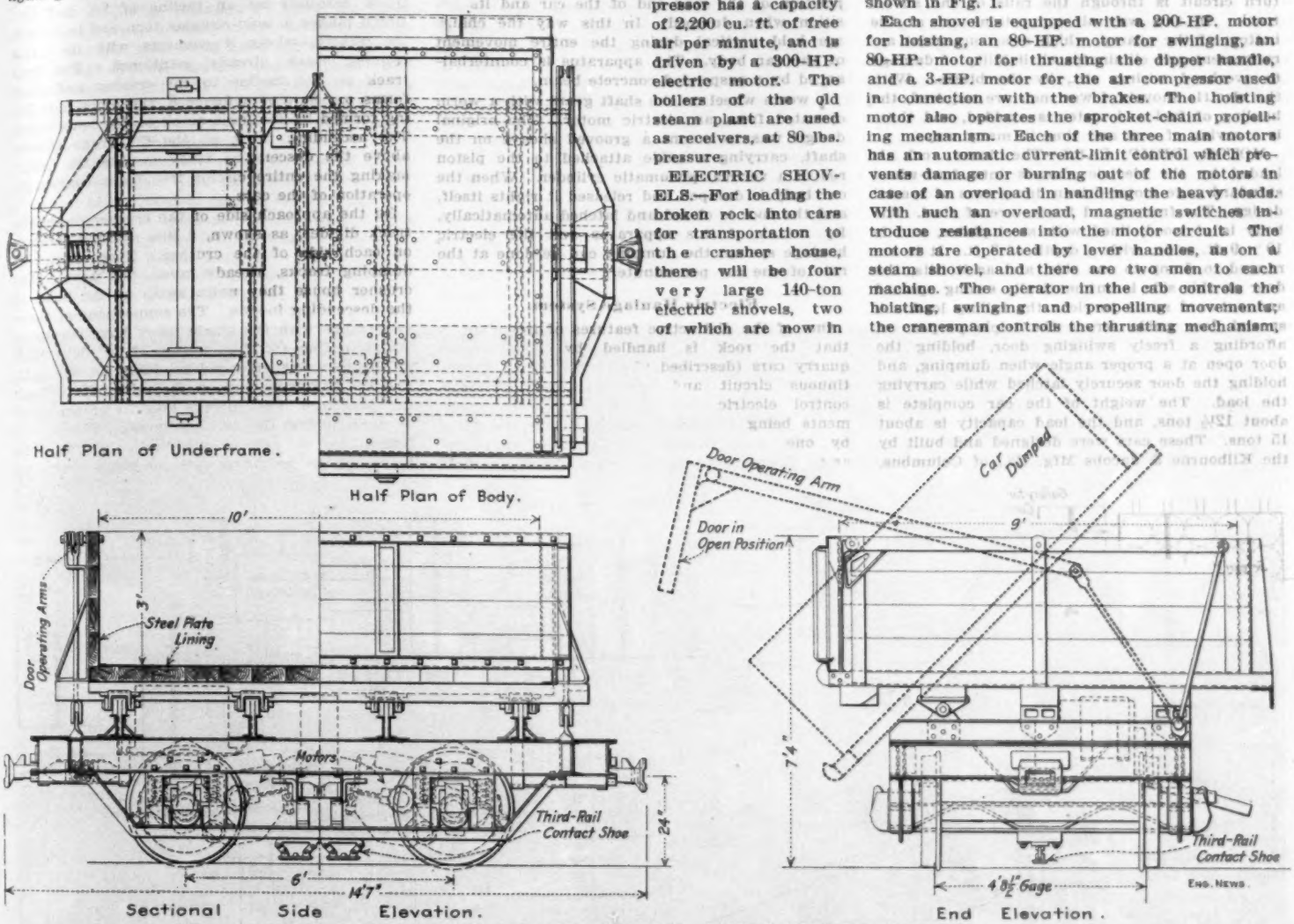

FIG. 4. ELECTRIC DUMP CAR FOR QUARRY HAULAGE SYSTEM.

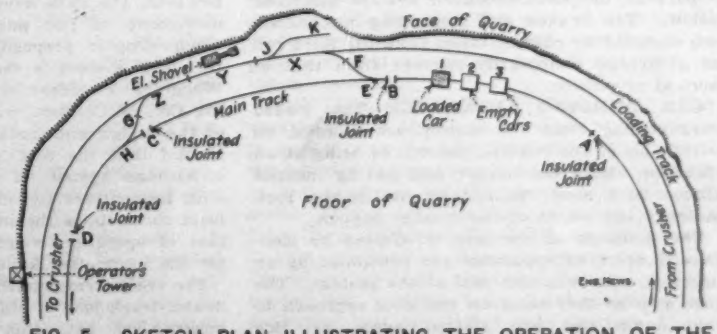

FIG. 5. SKETCH PLAN ILLUSTRATING THE OPERATION OF THE CENTRAL-CONTROL ELECTRIC HAULAGE SYSTEM.
Woodford Engineering Co., Chicago; Engineers.

flexible feed-cable, which is passed under the tracks and has one end clamped to the nearest conductor rail, being shifted as required. This cable is carried on a spool in the cab. The return circuit is through the rails of the shovel track. In this way all connections are at the bottom of the quarry, which is a convenient arrangement and eliminates all liability of damage to overhead wiring, etc., by the blasts. With the electric shovels, fewer men are required, the hauling of fuel and water is avoided, and there is a saving of cost and time in many ways.

MOTOR DUMP CARS.—The loose rock is loaded by the electric shovels into four-wheel standard-gage motor-driven dump cars of special design. The frames and trucks are of steel. The body is of wood, lined with steel plates, and is 10 × 9 ft. wide, with a depth of 3 ft. It is arranged to dump to one side, and as it tilts, the door on this side is automatically swung upward and outward so as to clear the falling load. A special door guide serves the triple purpose of affording a freely swinging door, holding the door open at a proper angle when dumping, and holding the door securely latched while carrying the load. The weight of the car complete is about 12½ tons, and the load capacity is about 15 tons. These cars were designed and built by the Kilbourne & Jacobs Mfg. Co., of Columbus, O. Fig. 3 is a view of one of the cars. Fig. 4 shows the construction of the car and its position when dumping.

Each car has two 30-HP. 220-volt motors and contact shoes taking current from the third-rail. The motors are of special design, and each has in connection with it a solenoid brake which forms a part of the electric-control system described below. The brakes and controlling mechanism are operated by current taken from the third rail at a voltage temporarily reduced from that of normal propulsion.

CAR DUMPING APPARATUS.—The loaded cars coming from the quarry are dumped on both sides of the crusher, the tracks being at an elevation above the hopper and having inclines (faced with steel rails) down which the rock slides to the mouth of the crusher hopper.

The dumping of the cars is effected by electrically operated apparatus and controlled by an operator who runs this part of the system. The cars stop as they enter on the level approach to this dump and are started again by this operator. They are brought forward and stopped at the crusher, dumped and started toward the quarry. At each dumping point is an overhead shaft (parallel with the track) fitted with two cams, to each of which is attached a chain ending in a hook to fit under the rear of the car body. When the lifting begins (and the load is heaviest) the chains are on the small end of the cam, operating at short radius. As the car tilts and the stone slides out (reducing the load) the larger arm of the cam comes into play and operates on a longer radius. The horizontal distance between the ends of the cams in their two extreme positions is equal to the horizontal distance between the normal position of the rear end of the car and its position when dumped. In this way the chains are held vertical during the entire movement of the car body. The apparatus is counterbalanced by a suspended concrete beam.

A worm wheel on the shaft gears with a worm operated from an electric motor. The original design was to mount a grooved sheave on the shaft, carrying a cable attached to the piston rod of a vertical pneumatic cylinder. When the car body is dumped and released it rights itself, and the door is closed and latched automatically. By means of this apparatus and the electric haulage system the dumping can be done at the rate of one car per minute.

Electric Haulage System.

One of the distinctive features of the plant is that the rock is handled by motor-driven quarry cars (described above) moving in a continuous circuit and operated by a central-control electric haulage system, their movements being controlled, except during dumping, by one man located in a tower so placed as to command a general view of the work. This is the first application of the system on such an extensive scale, and where several switching movements are involved. It has been applied at five brick yards and a packing establishment, and is proposed also for a coal-handling plant where numerous curves prevent the application of a conveyor system. In all these other cases, however, the cars have a shuttle or to-and-fro movement on two parallel tracks, which is a much simpler proposition than that at Gary, Ill. This system is the invention of Mr. F. E. Woodford, President of the Woodford Engineering Co., of Chicago, who has had entire charge of the design and installation at the quarry. It is said that the cost is not more than that of a haulage system of equal capacity equipped with locomotives (which latter would require at least three times the number of cars), while the cost of operation is materially lower than that for the locomotive haulage system.

The track arrangement is shown in Fig. 2. A double-track loop of standard gage is laid on the quarry bed, extending around its entire periphery, and having crossover tracks at intervals. The inside track, or that farthest from the sides of the quarry, is considered as the main track, and the other as the loading track. At the end of the quarry nearest the crushing plant a track leading off from the main track leaves the lower level and extends up an incline with a grade of 6% to the surface, where it turns a semi-circle with a 60° curve on a grade of 3% and extends further up on a steel trestle with a grade of 6% to the crusher house, which is entered at one side. The total elevation (at the dumping point) is about 40 ft. above the ground, or 80 ft. above the present lower level of the quarry floor.

After passing through the crusher house the track descends by an incline of 8% and 9%, which makes a semi-circular turn and leads into the quarry, where it connects with the main running track already mentioned. The loop track on the incline to the crusher and back forms one-half of a figure 8, the other half being formed by the main track on the lower level. The ascending track on the 6% grade crosses above the descending track on the 8% grade, making the entire circuit free for a continuous operation of the cars.

On the approach side of the crusher house the track divides, as shown, a line running through on each side of the crusher. These form the dumping tracks, already noted, and beyond the crusher house they unite again at the head of the descending incline. The connections of these two tracks with the single track have curves of 100-ft. radius and frog angles of 24° 36'. Half of the cars are arranged to dump on one side, and the balance dump on the other side. Each car, therefore, must always take its proper track in approaching the crusher house. This is effected by an electro-pneumatic switch, the valves of the operating cylinder being controlled electrically from two levers set at opposite sides of the track about 20 ft. from the switch. Each car has a trip, which is on one side of half the cars and on the opposite side of the other cars. This will throw the switch if it is not already set for the track which the car must take.

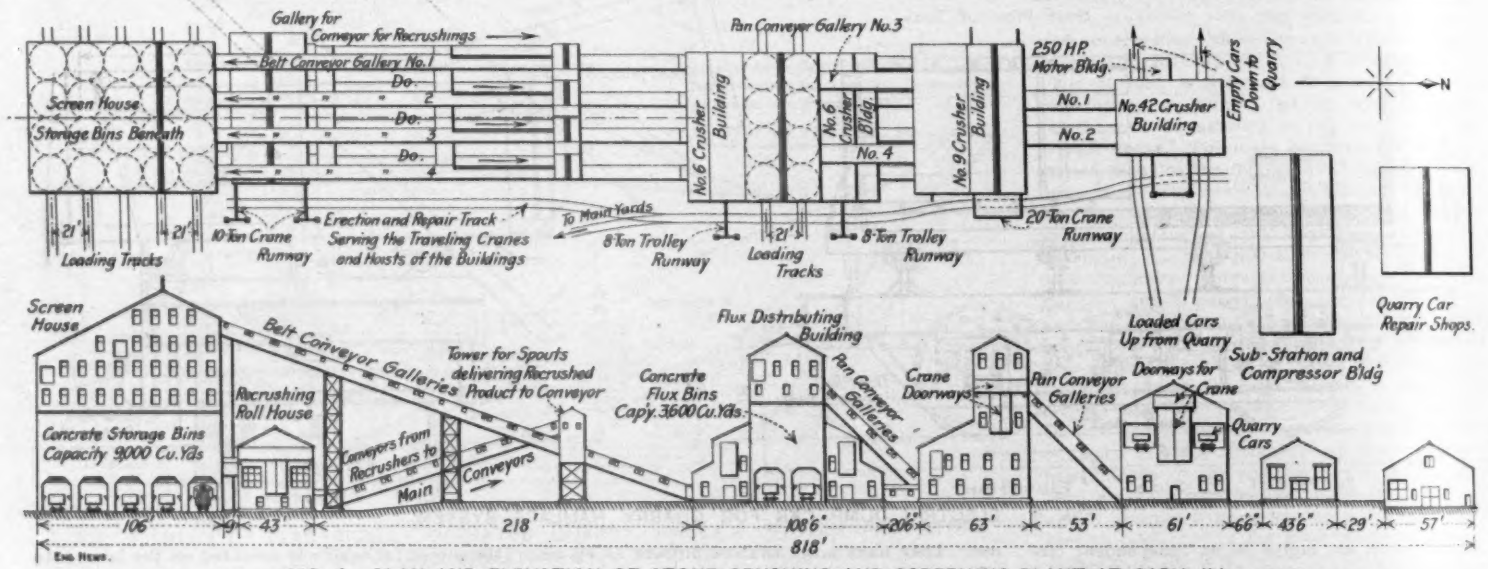

FIG. 6. PLAN AND ELEVATION OF STONE CRUSHING AND SCREENING PLANT AT GARY, ILL.

The permanent tracks on the inclines are laid with 70-lb. rails; the quarry tracks, which have to be shifted from time to time, are laid with 60-lb. rails. For carrying the current to the motors and the brake and controlling mechanism on the cars (already mentioned), there is a 25-lb. third-rail conductor laid between the track rails (and supported by insulators). This arrangement of the third-rail is the most satisfactory where (as in the quarry) the tracks must be in more or less imperfect condition and must be moved continually, as it maintains the proper relations of the third-rail to the track rail in spite of the above unfavorable conditions.

The cars are all controlled from a tower located at the edge of the quarry and near the crusher house, in sight of a large portion of the circuit of main and loading tracks in the quarry. From this tower, by the system of central control, each car may be operated independently from any of the others. It is possible to start it in either direction or to stop it with the brake upon any portion of the system of tracks over which it is being operated. The switches of the crossover tracks are electrically operated from the tower, so that the operator may keep a car on the main track or divert it to the loading track, as required. This switch operating

mechanism is on the electro-pneumatic system, with push-buttons in the tower controlling the electric valves of the pneumatic cylinder which operates the switch and with signal lamps in the tower to indicate how the switches are set.

It was originally intended to have the main controlling tower located near the crusher, in which case one man could have operated the entire haulage system, and dumped the cars. But as this main controlling tower was afterwards located in another place, it was necessary to provide controlling mechanism and a separate operator at the crusher.

Each of the electrically-operated shovels in the quarry is equipped with an auxiliary controller as a part of this central control system. By this means, the shovel operator manipulates the cars on those sections of the loading track which serve his machine; he places them in a position to be loaded, and moves them forward after loading to a position to be taken by the tower control. When in this latter position the loaded car operates a signal in the tower, indicating on which loading track a loaded car is ready to be taken up. In this position the car cannot be moved by either the shovel man or the tower man unless the main track is clear at this point or at the crossover to the main track. When the main track is clear at the crossover, the tower man brings the loaded car out upon the main track, and during this operation, should another car approach on the main track, its brake will be set automatically, making it impossible for two cars on different tracks to approach the same switch at the same time.

When the load is needed at the crusher, the car is brought forward (automatically selecting its proper track, as above described), dumped, and started on the downward trip. Upon the downward trip the car is automatically governed as to speed, usually requiring no attention from the operator until he desires to have it cross over to the loading track at one of the shovels. The downward trip of the cars is effected with the third rail dead upon this portion of the track. The car by its momentum becomes the motive power and the motor becomes the generator. The motors are series wound and it is only necessary to reverse the armature connection to make them operate as generators.

A certain amount of resistance is mounted upon the car and so adjusted as to form sufficient electrical load upon the motor, working as a generator, to give the car a certain predetermined speed. This operation forms the "dynamic brake" and will never allow a car under any condition to pass down any grade at greater than this set speed.

The third rail at this point, though dead normally, can be used by the main operator, just as upon the level portion of the track, to set the brake upon the car and stop it or to propel it back up the grade should he so desire, in an emergency.

That portion of the loading track upon which cars are controlled by the shovel operator has a capacity for several empty cars, and it is the duty of the tower man to so distribute the empty cars upon their return to the quarry, that each shovel will be supplied with empties at all times.

The level portion of the track leading to the crusher, and which divides into two branches extending on each side of it, has a capacity for a number of loaded cars. As these loads may be kept close together, and with the opportunity to dump them on each side of the crusher, it will be seen that the amount of raw material that can be delivered to the crusher is limited only by the number of cars in operation, and the facilities for loading them.

The control of the cars is resolved into (1) starting them from the shovels, (2) bringing them forward at the crusher to be dumped, and (3) starting them upon their downward trip. In an emergency a car may be stopped and started upon any portion of the track, but normally the operation of each car is continuous, not requiring the attention of an operator except as above. A car loaded at any one of the shovels will be 1,000 ft. or more on its way by the time the next car is loaded at the same shovel. This makes it possible for empty and loaded cars to be operated along the main track and distributed to and from the different shovels as they are needed.

The advantage of individual operation over that of making up trains of the loaded and empty cars is said to be very apparent. When a car is loaded it is not compelled to wait for other cars to be loaded, as is the case where cars are hauled in trains. With the plant running at its full capacity of 6,000 yds. per day of ten hours, 30 cars with this system are required to handle the raw material over approximately 6,000 ft. of tracks, while it is estimated that it would require 80 cars of the same capacity, were they to be made up and hauled in trains.

An automatic track-scale is installed on the loaded-car track on the incline, which weighs each load as it passes. Each car, by a non-interfering signaling device, indicates at the scale by which shovel that car was loaded. The weight of the load, and the number of the shovel loading it, are automatically marked on the recording tape at the same time. The tonnage of each shovel for the day is thus recorded at the scale, without any attention from the operator. In this way the work of each shovel is recorded automatically, and any failure to load a normal amount is evident and may be traced promptly.

FIG. 7. PART OF THE ELECTRICALLY OPERATED STONE SCREENING PLANT.

ELECTRIC CONTROL OF THE CARS.—The electric control of the cars from a central point is one of the specially interesting features of the haulage system, and is an important feature in the operation of the plant. The 220-volt motor current and the brake current (varying from 30 to 100 volts, depending on the number of cars operating in close proximity) are led to the 25-lb. third-rail mentioned before. All the control and operation is by direct-current. This conductor rail is divided into sections (separated by insulated joints), each section having independent connection with the controlling apparatus in the tower. Thus the car (or cars) on each section can be controlled independently of those on any other section. With more than one car on a section, however, all these cars are controlled in the same way, as a unit.

The control applies to the motor and the brakes of each car, and is effected by special controllers in the tower. Each of these has a

single lever. In one position it throws the current into the motor; in the other position it actuates a brake mechanism at the motor. The one motion of the operator's lever delivers current to the motors in much the same manner that an old street-car controller delivered current to the motors upon the car. The reversing movement in the first place decreases the voltage of the current flowing in the same direction, and this change of voltage actuates a relay on the car. This relay in its turn operates a second relay which breaks the motor connection and closes the brake circuit, sending current through the brake solenoids at the somewhat reduced voltage then on the third rail. The operator's controller has four steps in the braking movement so that after braking has started the voltage may be changed to increase the brake pressure. The movement throwing the motors into use has five steps to allow a gradual acceleration.

The second relay on the car has a compound winding which is affected by increase in voltage and by decrease in current supplied to the car over the amounts of normal operation on a level. When the car begins to descend a grade, therefore, the second relay acts to reverse the motor armature and set the "dynamic brake" into operation. There is no condition of haulage that is not met and manipulated from the tower; operating the cars in either direction individually or collectively, or setting the brakes. Exactly how all this is done can be shown only by electrical diagrams, which have not yet been published by the inventor.

Each controller in the main operating tower directs the movements on three or four sections of the third-rail by selective switches in the tower. Both the low-voltage and the high-voltage apparatus are protected by fuses and circuit breakers.

Voltage change for car control is made only on those sections on which switching is required. On the other sections, the third-rail receives simply the main voltage of propulsion, and the cars operate over these sections without control. Should a car, following another down a grade, approach too close, its brakes would be applied automatically by current from the first car, so that rear collisions are provided against. The motor would act in the same way if a car ascending the incline to the crusher should start to run away owing to the circuit-breaker opening or the current failing.

The general working of this system may be explained by reference to the sketch plan, Fig. 5. This shows a portion of the two parallel belt tracks which extend around the quarry, the inner one being the running or main track, and the outer one the loading track. At each loading shovel, these tracks are connected by a pair of crossovers, as shown. The movements are controlled by one man in the elevated tower, who operates levers for the electric controllers on the cars and push buttons for the electro-pneumatic track switches of the crossovers.

Suppose three cars are running on the main track on section (A-B). The first car (1) is loaded and going direct to the crusher plant. The switch at (E) is open and the car passing into section (B-C) continues on its way. As soon as this car has passed the switch, the switch (E) may be closed by the tower man, and the next car diverted onto the crossover. As soon as car (2) has passed the insulated joint at the end of section (A-B), however, the brake can be set on car (3), to hold it on (A-B) until required. Both cars, (2) and (3), can be switched at (E) if desired. The car (2) on the turnout section (E-F) is under control of either the tower man or the shovel operator, as the section of third-rail to which the turnout section (E-F) is attached has a joint lead to each of these men.

The loading track which serves the shovel is divided into three sections (X), (Y), (Z), each

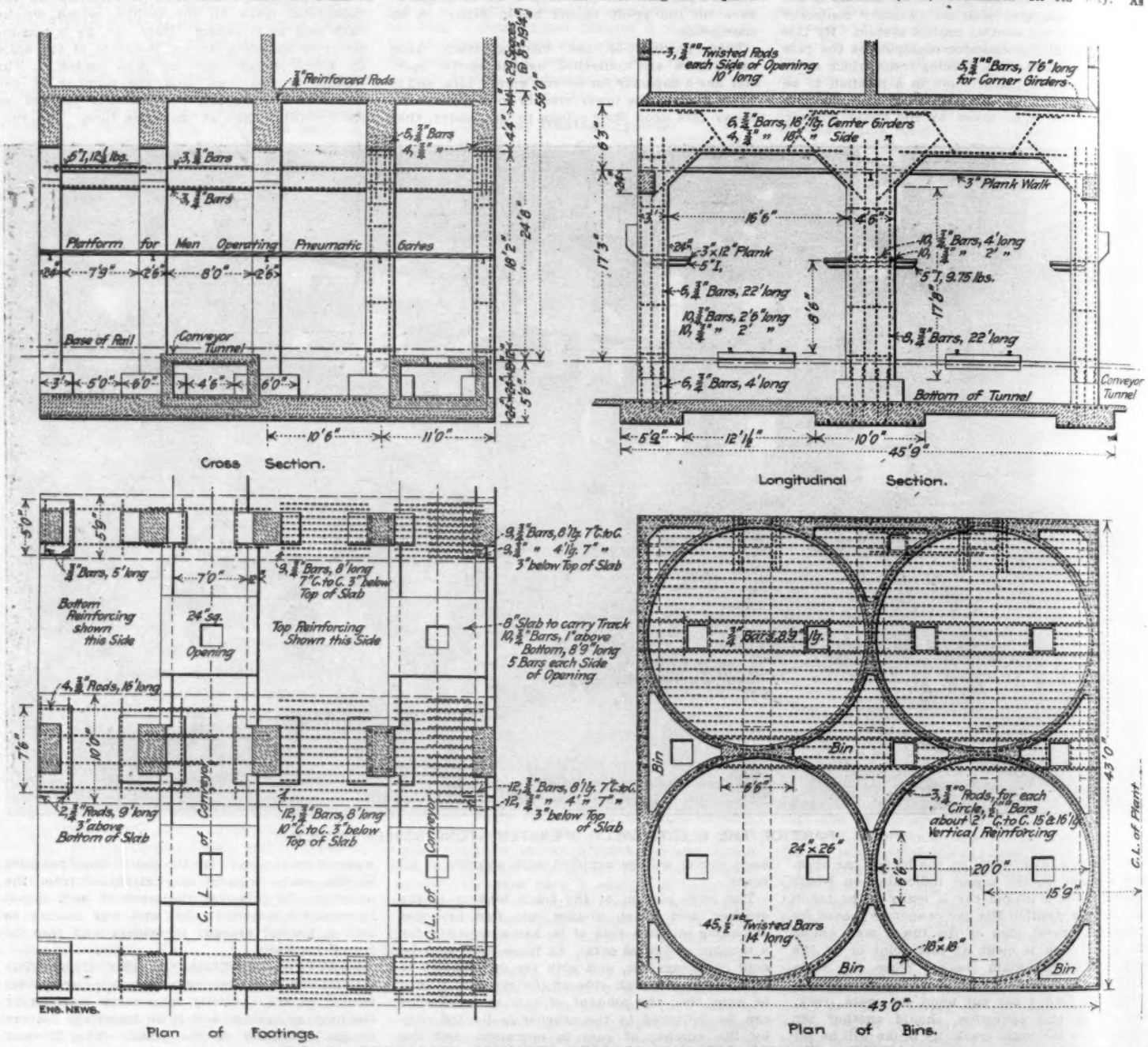

FIG. 8. REINFORCED CONCRETE STORAGE BINS FOR CRUSHED STONE.
Storing 4-in. Stone for Blast Furnace Flux.

having a separate control lead, and controlled by a separate lever on the shovel. With the shovel in the position shown, and an empty car needed, the shovel man throws his levers for (X) and (Y), and causes the car on (E-F) to move into position on section (Y); he then reverses the lever so as to apply the brakes on the car and stop it at the required loading point. The three sections of the loading track are separated by insulated joints on the third-rail. An open space would suffice for insulation, but a joint is used for mechanical connection in order to hold the rails in line.

The car being loaded, the shovel man throws his lever for sections (Y) and (Z), causing the car to run to the other end of the turnout. When the car enters the turnout section (G-H), it will be stopped automatically by the setting of its brakes if a car is running on the main line section (C-H). The shovel man cannot move the car beyond (H), but when the line is clear, the tower man will cause it to run out of (H) upon the main line, when it will continue its course automatically to the crusher plant.

After the car has passed out from the loading track to the main track, it is unnecessary for the tower man to pay any further attention to it, as it runs out of the quarry and up the incline to the crusher house, where it stops automatically on the level track outside the building. He can, however, stop and start the car at any point during this movement, should it be necessary. As fast as stone is required for the crusher he moves the cars forward to the dumping point, holds them for dumping, and then starts them again on their way to the quarry. They run then automatically and the operator resumes control only when it is necessary to switch them to any desired loading track.

The facing switch (E) is an electro-pneumatic switch controlled by electrical interlocking from the tower, and operated to keep cars on the main track and divert them to the loading track, as required. The trailing switch (H) is simply a spring switch, requiring no operation. Ordinarily, the tower man can see the movements of cars at all turnouts. To ensure accuracy of movements, however, and to provide for foggy days when the cars cannot be seen, the sections (G-H) and (C-H) have an automatic miniature semaphore in the tower. When the semaphore is lowered it indicates that (C-H) is clear, so that a car may be moved out from (G-H) to the main line. If the semaphore is raised, however, it indicates that a car is running on (C-H), so that a car on (G-H) must be held. The electro-pneumatic track switches are operated by push buttons and indicated by red and green lights in the tower to show in which position the switches are placed; the green light being for the main track and the red light for the siding. This arrangement of track sections, switches, signals, etc., is of course duplicated at each shovel. The movements as described provide only for forward movements. Provision is made, however, for reverse movements in case a spur or stub loading track is required, as at (J-K). This includes control of the switch at (J) and the means of control for reversing the motors on the cars. The wires for the 15-volt electro-pneumatic, track-switch and signal circuits are laid in compartments of the same trunking that covers the conductor rails for the electric loading shovels on the floor of the quarry, already described. There is practically no loss of the 220-volt current by leakage even in wet weather, owing to the comparatively short stretch of line and to the insulators. For still shorter lines, the third-rail has been spiked to wooden blocks on the ties without causing trouble in this respect.

Stone Crushing and Screening Plant.

All the product of the quarry is delivered directly to one enormous crusher by the motor dump cars and haulage system above described. This is the first unit of the crushing and screening plant, and occupies the first of a row of buildings which extends directly away from the quarry (as shown in Fig. 2). The arrangement of these buildings is shown in Fig. 6. The buildings are partly of concrete, and partly of structural steel with galvanized corrugated steel sheathing. The conveyor galleries and the screen houses on top of the storage bins are of the latter type of construction. In each building there is a Whiting overhead electric crane or a trolley hoist for handling the machinery in erection and repair work. The runways for these extend outside the building, so that the cranes and hoists command cars on a side track which runs along the row of buildings.

CRUSHERS AND SCREENS.—A feature of the crushing plant is the great size of the first crusher, which is of the McCully gyratory type. The Dolese & Shepard Co. began in 1877 with a No. 3 crusher and has installed larger and larger machines until now the main crusher of the new plant is a No. 42 (the largest made), having a 20-ft. hopper top with a two-arm spider giving two openings 42 × 96 ins. to receive the broken rock from the quarries. It is driven by a 250-HP. motor by means of a rope transmission system. Its nominal capacity is an output of 8,000 tons of stone per 10-hour day, but it is estimated that this may be 50% greater in actual service, if required. The size is not only to increase the capacity, but also to reduce the amount of labor otherwise required to break up the larger quarry blocks so that they can be fed to the crusher.

The main shaft is 30 ins. diameter and weighs 15 tons; the 70-in. crushing head weighs 17½ tons, and the spider 41 tons. The total weight of the machine, erected in place, is about 212 tons. The eccentric bearing which gives the gyratory crushing movement runs in a 300-gal. bath of oil to eliminate any danger of a hot bearing. This crusher is practically identical with those built for some cement companies and described in our issues of Sept. 19, 1907, and June 4, 1908.

This main crusher reduces the stone to a 6-in. size, and discharges its product through two openings upon either or both of the two parallel pan conveyors above mentioned. These are of special design, having overlapping buckets 54 ins. wide, and 24 × 24 ins. in section, which are attached to steel bars having flanged wheels riding on the conveyor tracks. These conveyors are 114 ft. long on an incline of 45°. They elevate the stone to the top of the next building, and deliver it to a large steel bin from which it is fed automatically to two No. 9 Gates gyratory crushers, each driven by a motor of 100 HP. These reduce the stone to a size of 4 ins. or less, and each crusher delivers its product to two revolving screens 4 ft. diameter and 24 ft. long. These are of manganese steel. The 2½-in. stone which passes through the perforations in the screens is delivered to belt conveyors, noted below.

The stone rejected by the screens, 2½-in. to 4-in. size, is delivered to two elevating pan conveyors having buckets 4 ft. wide and 24 × 24 ins. in section. These conveyors are 120 ft. long and have an angle of 45°; each is driven by a 60-HP. motor. These rejections, known as "flux size," are delivered by the pan conveyors into the eight bins of the flux storage building.

All or part of this stone (not needed for furnace flux) can be delivered directly to eight No. 6 Gates gyratory crushers (four on each side of the flux storage building). These crush to a 2½-in. size, and each is driven by a 50-HP. motor. This product, and the 2½-in. product from the screens at the No. 9 crushers, is delivered to four 24-in. belt conveyors running horizontally. These deliver the stone to four 30-in. belt conveyors which have an angle of 23° and a length of about 350 ft., delivering the product to the main screen house, which is located on top of the main storage bins. Each is operated by a 60-HP. motor.

The main screen house will contain 24 screens, as follows: 8 revolving screens 4 ft. in diameter and 28 ft. long with 16-ft. jackets; 8 revolving screens 4 × 24 ft., and 8 shaking screens 3 × 12 ft. A part of the screening plant is shown in Fig. 7. Each of the four belt conveyors discharges into two of the 4 × 28 ft. revolving screens, whose rejections are in turn discharged into the 4 × 24-ft. screens, which have larger perforations. The stone that passes through the ½-in. perforations in the upper end of the first revolving screens is delivered to two of the shaking screens, which separate it into smaller sizes, and it is then passed to the storage bins.

The rejections from the screens are delivered by horizontal conveyors to a re-crushing plant consisting of two sets of rolls 54 ins. diameter and 24 ins. wide, having the faces fitted with chilled-iron corrugated plates of the herring-bone pattern. There are also two sets of crushing rolls 36 × 16 ins. for crushing to sizes of ½-in. or less. The completed plant will have four sets of 54-in. rolls and four sets of 36-in. rolls. The rolls are belted to shafts, each shaft serving one large and one small set of rolls, and being driven by a motor of 100 HP.

The horizontal conveyors mentioned were designed specially for this work, and each consists of a rubber belt fitted with transverse steel plates a few inches wide, bent up at the ends to form a rectangular trough. They are fitted with speed-changing devices, so as to vary the amount of stone delivered to the rolls in accordance with the size of the product from the rolls. This recrushed product is delivered to a 24-in. return belt conveyor, rising at an angle of 20°, which delivers it at an intermediate point on the main conveyors for its second delivery to the screens and storage bins. The recrushing plant is used not only to handle the rejections, but also to reduce the larger sizes in storage to such smaller sizes as may be required to fill orders from time to time.

The arrangement of the plant is designed to allow of subdivision into separate plants which can be operated together or singly according to the required capacity of output. The stone leaving the one large main crusher can be delivered to one or both sides, as desired. Beyond this the machinery is arranged to constitute two separate plants, each of the No. 9 crushers (with its elevators and screens) constituting an independent plant delivering to the flux storage bins. Beyond these bins, the plant is divided into four separate groups, each being so constituted that it can be operated alone or with others in delivering the finished product. Each of these four groups includes two No. 6 crushers, 6 screens, 2 sets of rolls, and the necessary elevators, conveyors and storage bins.

The crushers, screens, rolls, conveyors, etc., are all operated by induction motors, and all the larger machines have individual motors.

Storage Bins.

The broken stone is discharged into cylindrical storage bins of reinforced-concrete construction, each bin having a capacity of 500 cu. yds. The bins are 20 ft. inside diameter and 32 ft. high, with walls 8 ins. thick (12 ins. at the points of contact with adjacent bins or the side walls of the building). The spaces between the adjacent bins and between the bins and the walls of the building are all utilized for storage. The bottom of the bins is formed by a 14-in. slab of reinforced concrete which covers the entire area of the building. This is at a clear height of 22 ft. above the rails of tracks passing under the bins and is supported by girders on heavy rectangular columns. The walls, girders and columns are all of reinforced concrete. Their construction is shown in Fig. 8, which represents the flux storage building.

The stone storage facilities are divided into two units: the screening storage building of 5,000 tons capacity for stone of various sizes, and the flux storage building of 2,000 tons capacity for 4-in. stone used as blast-furnace flux. Provision is made for doubling the size of the storage facilities when required. The flux storage building has four bins (eight for the complete plant when enlarged), in two rows, with a loading track passing under each row. The main storage building has ten bins (20 for the complete plant) arranged in five rows, with a loading track under each row.

Each storage bin is fitted with a spout and outlet gate, from which the crushed stone falls directly into railway cars for shipment or onto belt conveyors to be carried back for recrushing to smaller sizes, according to the demand. The

spouts have openings 24 × 24 ins. The gates are of segmental type and are operated by compressed air. The pipes are led to valves grouped at elevated platforms supported by brackets on the columns, and from each point a man may control four gates. A 50-ton railway car can be loaded in this way in about one minute. The loading tracks connect with a single lead track, so that cars from a train of empties can be set on any of the loading tracks, as desired (see Fig. 2). On each track under the bins there will be a track scale, to weigh the stone as it is loaded. This will ensure that each car is given a full load, but not overloaded.

This plant, as already noted, can supply stone of any size from riprap to a fine dust that passes a 100-mesh sieve.

A Description of Four Stadia Surveys and Their Cost.

By ARTHUR W. TIDD,* Assoc. M. Am. Soc. C. E.

In 1905, topographical surveys were made by the New York Aqueduct Commission for an additional reservoir in the Croton drainage area near the village of Croton Falls, New York, and at the junction of the East, West and Middle branches of the Croton River. A total of over 3,000 acres were surveyed, the main portion being roughly 4 miles long and 1 mile wide. The

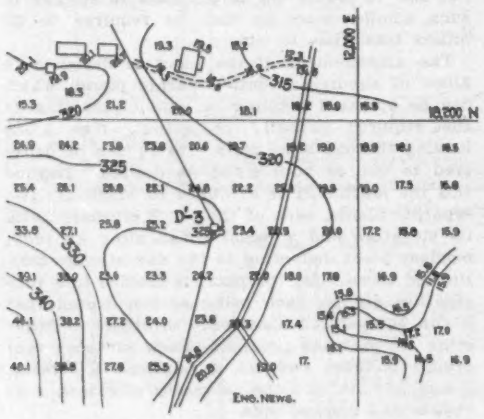

Fig. 1. A Typical Portion of the Topographical Map.

stadia method was used entirely and this paper describes the methods used by one party for conducting and systematizing the work, some of which are believed to have been new at that time. Cost data of the field work and a brief description of some of the office operations are also given.

The reservoir, Croton Falls Reservoir K, is now under construction.

The topography of the basin is typical of the Croton drainage area, rolling and irregular, but not precipitous. The valley is under cultivation or used for pasturage for the most part, the percentage of genuine woodland being small. Orchards are numerous, however, and cause nearly, if not quite, as many delays as woods.

THE MAP.—A large topographical map of the entire reservoir site was made on a scale of 1 in. = 200 ft. and smaller additional maps of the various dam sites on a scale of 1 in. = 40 ft.

The large map had 5-ft. contours and showed the railroads, highways, buildings, streams, etc., but no walls or fences; the smaller maps of the dam sites had 2-ft. contours and showed, in addition, the ledge outcrops and many other details required for studies, designs and estimates.

Everything was referred to a rectangular system of coordinates, the coordinate lines on the maps being drawn 12 ins. apart. A reproduction of a portion of the map is shown in Fig. 1. In the original the traverse lines are vermilion, the elevations and roads black, the streams blue and the contours burnt sienna. Note the hundreds of the elevations omitted, except at stadia stations. The decimal point is the location of the shot.

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THE CONTROL.—The control was furnished by a number of "base traverses" which were run along the roads and in a general way crossed and encircled the reservoir. They were carefully run, the courses being measured with a steel tape and the angles turned with care. The primary object was to furnish the control for the subsequent property surveys, but they were very convenient to tie the stadia traverses to; the stations, of course, were not advantageously situated for the taking of topography. Some 18 miles of "base traverse" were run.

BENCHES.—The bench leveling was done with an ordinary wye level and New York rod. Benches were established at frequent intervals on bridge abutments, ledges, or roots of large trees. The circuits totaled about 16 miles.

The Survey.

The traverses were run by the ordinary stadia methods and checked out with an error of two minutes in azimuth and from 0.2 to 0.4 ft. in elevation without any difficulty.

The running of the traverse and the taking of topography were entirely independent of each other. The first operation was to run the traverse, establishing the stations, turning the azimuths and reading the distances, but not taking any topography. The engineer in charge of the party personally selected each station. Having in mind the whole broad area to be surveyed he could size up the controling conditions, such as wooded areas, impassable streams, the location of the flow-line, the limits of previous work, the maximum length of shot allowable, etc., and locate the stations to the best advantage. The judicious selection of the stations is essential to rapid and economical work and will warrant some deliberation. Not only must the maximum amount of country be covered from each set up, but it must connect with the previous work and be left with such an outline that the next set up can readily join on. If gaps are left special traverses have to be run to fill them in and such work is expensive. As each station is located the limits of the work to be done from it are mentally planned, a road, a wall, the edge of some woods, or a brook, lending itself to the purpose, forming well defined boundaries, easily remembered, and readily picked up again even after an interval of several weeks.

As before stated, the chief of the party and a couple of men went ahead putting in the stations. The transitman followed along over them as fast they were established reading the azimuth, distance and vertical angle. At each setup, in addition to the azimuth of the traverse, two others were taken to prominent objects, which were permanent and which could be clearly described, a church steeple, a weather vane, a flag pole, etc. By means of these sights the transitman was enabled to pick up the azimuth himself without any assistance from the rodmen when the stations were later occupied for the purpose of taking topography. Thus all the work of carrying and driving stakes, chopping out line, giving sights, etc., was accomplished at one operation. All the stations were established and the traverse checked out before any topography was taken, thus any error of azimuth or elevation was discovered and corrected before it had run through page after page of stadia notes.

With the azimuths and elevations determined, the stations were again occupied for topography. Three rods were used, the rodmen working together in parallel straight rows (about 100 ft. apart for 5-ft. contour work and 60 ft. for 2-ft. contours) taking shots at regular intervals (30 paces for 5-ft. contours and 20 paces for 2-ft. contours) even when the country was flat or on a uniform slope. Shots were taken in rotation and each rodman kept on his own line as a general rule, but in some cases would sidestep in order to make his shot more representative or to locate some special object, returning to his line immediately afterwards. They traveled back and forth across the area in a regular system, as shown by Fig. 2.

"A" and "C" alternately furnished the guide and it was up to them to figure out ahead the point to run to on the return trip in order to keep the lines parallel. The rods were kept abreast of each other as far as possible. Only one rod was allowed to be vertical at a time (this rule was strictly enforced), thus the transitman never got confused and no doubt occurred as to which rod was meant when the "all right" signal was made. Having covered the area planned to be taken from one set-up, the head of the party gave the signal to the transit, the rodmen moved over into position for the next trip and were at liberty to rest. The transitman moved ahead onto the next station, picked up his azimuth

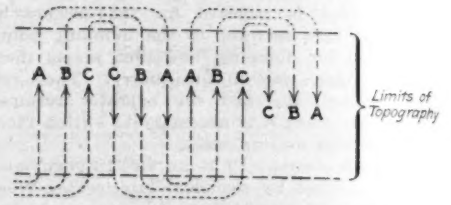

Fig. 2. Diagram Showing Routes Followed by Three Rodmen.

from one sight, checked it on the other and was ready for business again.

By this method the rodmen confined their entire attention to the taking of topography; there was no running around to give backsights, bring up stakes, or pick out the next station. The work was pushed steadily ahead and there was small chance of anything being overlooked or forgotten.

A word about the rodmen "resting" may not be amiss right here. The head of the party usually accompanied the center rodman and, on a large portion of the work, carried a pedometer. The records (some of which appear later) showed that 12 miles was not at all an unusual day's work, and when one considers the general character of the traveling in ordinary country, up and down hill, over walls and barbed wire fences or through meadows, a brief rest is mighty welcome at times. Then, too, the men will do more work if they know that they are always sure of that intermission. It is the party that knows that they will get the word to stop promptly at twelve and that the day's work is over at five sharp every night, that turns out the most work. The party that never knows when the dinner hour is coming loses its interest in the work and spends most of the time after half past four

	at D'—3		H 1 4.85		325.51	White Steeple N Edge red Barn
	122—40½					
	87—16					
H_{71}	191—42	112	—0"—36'	—1.3	324.2	
W_{72}	183—48	215	—0 —27	—1.7	323.8	
K_{69}	186—45	322	—0 —07	—0.7	324.8	c + w L 15 4 ~
H_{72}	134—40	155	—1 —18	—3.5	322.0	
W_{77}	165—05	232	—0 —33	—2.2	323.3	jc + w
K_{68}	157—50	340	—1 —06	—6.5	319.0	c + w
H_{73}	121—00	220	—1 —55	—7.5	318.0	
W_{78}	138—50	282	—1 —38	—8.1	317.4	
K_{70}	143—35	383	—1 —10	—7.7	317.8	
H_{74}	111—16	294	—1 —30	—7.7	317.8	
W_{79}	128—00	336	—1 —44	—10.1	315.4	W Edge River
K_{71}	132—30	400	—0 —29	—9.4	316.1	" " "
H_{75}	105—22	418	—1 —12	—8.6	316.9	
W_{80}	117—12	354	—1 —35	—9.7	315.8	" " "
H_{76}	101—30	512	—1 —06	—9.7	315.8	" " " + 6 4 ~
W_{81}	115—05	472	—1 —06	—9.0	316.5	" " "
K_{72}	124—10	518	—1 —05	—9.6	315.9	

FIG. 3. PAGE OF STADIA NOTES.

looking at their watches and wondering whether they will catch the five fifteen or the five fifty.

The foregoing description gives the general method used for all the stadia surveys. Modifications were, of course, necessary in the villages and where heavy woods were encountered, but the division into the two separate and distinct operations was always adhered to. Some of the details may be of interest. In running the traverse it was the practice of this party to carry along the azimuth directly, instead of measuring the angle at each station. The recorder kept the elevations worked up by means of the little book "Stadia Surveying"* by Arthur Winslow. When giving foresights and backsights the rodmen plumbed the rod carefully by means of a plumb bob or rod level. The recorder usually took the transit box along for a seat; it came in handy for other purposes, too. In open country with three rods and a fast instrument-man, he will have all he can do to keep up, and he should be as comfortable as possible, especially in cold weather. When working in the vicinity of the flow-line the head of the party determined the limit of the topography by means of a hand-level and certain conspicuous objects around the basin that were about the proper elevation, a church spire, a prominent barn, etc. Working from one to another a number of such landmarks were soon spotted, some of which were always in sight. Side notes were shouted by the rodmen at brooks, roads, etc., to supply the additional information required by the draftsman. They were instructed in the art of yelling these side notes, for when shots are coming in at the rate of three a minute the recorder has no time to rearrange the things that come to his ears. The transitman's distance, azimuth and vertical angle go down word for word and the side note should be equally adapted to him. To that end all unnecessary words were eliminated, stereotyped terms used as far as possible and words selected that could be sharply and clearly enunciated, for instance the staccato "edge of brook" will carry better and more distinctly than "bank of stream." When locating roads the shot would be taken in the center of the traveled way and the single word "road" called out, occasionally giving the width, the words "center" or "angle" being unnecessary. At the intersection of two roads the note was "junction of roads."

THE NOTE BOOK.—The ordinary type of bound field note book was used, the left-hand page being used for the readings and reductions, the right for side notes and descriptions. Fig. 4 shows the notes of a complete traverse starting from the base traverse A at station 33 + 61.25 and closing on base traverse B. The reference to the book and page of the original notes of the base traverse are given and the closing error of elevation and azimuth shown. Note the two azimuths for use when the set up is made for taking topography. In the column of elevations the unadjusted elevations appear crossed out and the final adjusted elevations given below showing the distribution of the error which, on account of local conditions, was not always proportionate to the distance. It was not customary to adjust the azimuths unless several traverses were to be looped onto one another—this "looping" was studiously avoided, every effort always being made to tie up on a base traverse. Level readings were always taken when possible, but under no circumstances was a level reading and a vertical angle combined; unless both readings could be level, vertical angles were used. The instrument constant (1.00) was used in working up the traverse, but nowhere else. Fig. 3 is a portion of a page of topography notes and shows when plotted in Fig. 1. The first column is the rodman's letter and the number of his shot, each rodman's shots being numbered consecutively, beginning with one each morning. If sketches are needed these numbers are used to indicate the position of the shot. When starting out, or when something happens to interrupt the rotation of the shots, the instrumentman calls out each rodman as he reads, but usually all that is necessary is an occasional check. The — 6.0 in the vertical angle column on shot K71 means that the instrumentman was unable to see the H I (4.85) on account of some obstruction and had to use the upper portion of the rod, setting on 10.85 and calling "correction minus 6 ft." to the recorder when reading the distance. The correction must be properly called plus or minus and can then be added algebraically to the difference of elevation obtained from the vertical angle. Similarly the rodman may be in high brush and have to hold the rod on his shoulder in order to make it visible, in which case he would shout "correction minus 5 ft.," or whatever the proper correction was. Corrections can, however, usually be avoided by a little ingenuity on the part of the rodman. The side notes are interpreted as follows:

/, higher; \, lower; L R, level reading; C T W, center traveled way. +, —, R, L (plus, minus, right and left), always refer to the transitman's right or left, for instance + 5, 7 \ means that 5 ft. farther along the line of the shot from the transit the ground is 7 ft. lower and is shouted "plus five seven lower."

THE INSTRUMENTS. — The transits were either Buff and Buff or Berger, erect, 5½-in. circle graduated from zero to 360° in either direction. The rods were home made, as shown in Fig. 5, a T section built up of ½-in. pine, 3 to 3½-in. face, 15 ft. long, weighing 7 lbs. The graduations were black on a white ground, the numbers being black, with the exception of the 5 and those above 10, which were red. The red 5 enables the instrumentman to catch his H I quickly and the 1, 2, 3, etc., above the 10 indicate that they mean 11, 12, 13, etc. The bottom of the rod is filled in solid and shod with heavy galvanized iron. The graduations are exact feet and tenths, beginning with zero at the bottom of the rod. The instruments had fixed stadia wires, the spacing was correct so that there was no initial error and, although readings were taken over a measured course about once a month, no corrections were ever found to be necessary. The level on the telescope and the zero of the vertical arc required some adjustment at times.

		at A 33 + 61.25		H.I. 4.82	247.60	Bk. 3 pg. 47 fork of rds. near Gregory.
A 30 + 18.13	192—15—40					
A'—1	87—40	1428	+0—36	+15.00	~~262.41~~ 262.53	S. side of wall on knoll.
		at A'—1		H.I. 4.05		
A 33 + 61.25	267—40	1432	—0—35	—14.62		
A'—2	101—33½	1070	L.R. 5.17	—0.22	~~282.17~~ 283.38	edge of borrow pit near cemetery. white steeple. peak of tower on brick house
	23—38					
	40—17					
		at A'—2		H.I. 5.00		
A'—1	281—33½	1070	L.R. 4.74	+0.26		
A'—3	80—16	906	—0—12	—3.18	~~259.99~~ 259.27	E. edge river, 500 ft. below bridge. white steeple. N. edge red barn.
	22—55½					
	121—40					
		at A'—3		H.I. 4.05		
A'—2	260—16	904	+0—12	+3.17		
B 14 + 20.55	98—22	1018	+1—22	+24.26	~~283.15~~ 283.51	big pines should be 283.51 bk. 7 pg. 14. E. edge E. chimney, Gregory. E. edge W. chimney, Gregory.
	350—18					
	345—27					
		at B 14 + 20.55		H.I. 5.05		
A' 3	278—22	1020	—1—21	—24.05		
B 18 + 40.97	173—36					should be 173—35—00 bk. 7 pg. 14.

FIG. 4. A PORTION OF A PAGE OF TRAVERSE NOTES.

REDUCING THE NOTES.—For reducing the rod readings to differences of elevation the diagram shown in Fig. 6 was used principally. The vertical angles radiate from a center at the lower left-hand corner and are shown on the upper and right-hand edge of the sheet. When in use the sheet was pinned down, the angles indicated by means of a thread fastened at the zero point and operated by the right hand, and the differences of elevation read on the left-hand edge. Two more sheets made up a set, matching on top of the one shown, but they were seldom used. For extreme vertical angles another diagram was required to correct the horizontal distances. Fig. 7 shows the first sheet of a stadia reduction diagram used by the writer on some subsequent work. No string is required, all the quantities being read off directly. For mechanical devices the 10-in. Keuffel & Esser stadia slide rule was found to be very satisfactory. The operation of reducing the notes ordinarily took two men (one reading the notes and one running the diagram) for the first reduction, which was later checked by two other men using the same method. Sometimes two diagrams, or a diagram and a slide rule, were worked simultaneously from one reading and the reductions checked then and there.

It is impossible to say which diagram is the best or most rapid, each is perfectly practical, having been tried out on a large scale. Each one has it advocates, and one method fits the personal equation of one man better than the other. Rapid progress can be developed with each.

PLOTTING THE NOTES.—Fig. 8 shows the protractor that was used. It is quickly made and from ordinary inexpensive materials that are always available. Any one can make one and it will stand up under the constant use of the draftsman and the rough handling by the field force on rainy days. A 14-in. cardboard protractor, a few paper scales and a bit of celluloid (an old film is good) are all that are required. The protractor is cut away as much as is consistent with strength and stiffness for handling in order to cover up as little of the map as possible. The central portion is fitted in when setting up and orienting and removed as soon as weights, which hold the protractor in position, are placed. The edges are graduated (a strip of cross-section paper pasted on is convenient) so that the protractor can be oriented by means of the coordinate lines without reference to the traverse

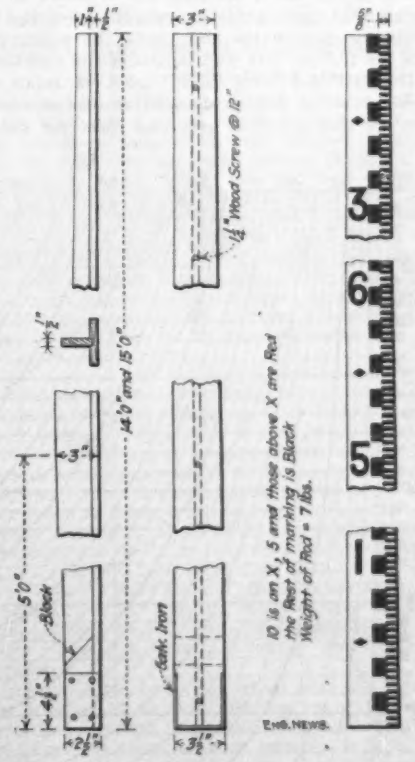

Fig. 5. Stadia Rod Used on Surveys of the Croton Falls Reservoir.

*No. 77 of the Van Nostrand Science Series.

line. At the zero of the plotting scale is a bit of celluloid pierced for the needle point that serves as the pivot.

The traverses were usually drawn on tracing paper, the error adjusted graphically and the stations pricked through onto the map. A more satisfactory method and one which will not take much longer is to compute the traverse with a large slide rule, adjust it roughly, plot the stations by coordinates and check the plotting by scaling the azimuth and length of the courses.

INTERPOLATING CONTOURS.—A small volume could be written descriptive of the various devices that are seen here and there for the interpolation of contours. Oftentimes one's eye is amply good enough, sometimes two men can work to advantage, one reading the position of the contours from a diagram, but it is essentially a "one man job" and each will ultimately work out some scheme to suit himself. The device shown in Fig. 9 is well adapted to this class of work and can be quickly made. It consists of a piece of Plate A profile paper about 6 ins. wide and 10 ins. long, large enough to be held in place with the wrist, while the fingers and the other hand operate the triangles. A portion of one edge is graduated in both directions. In use the scale is set on one elevation and by means of two small triangles the contour points are paralleled in.

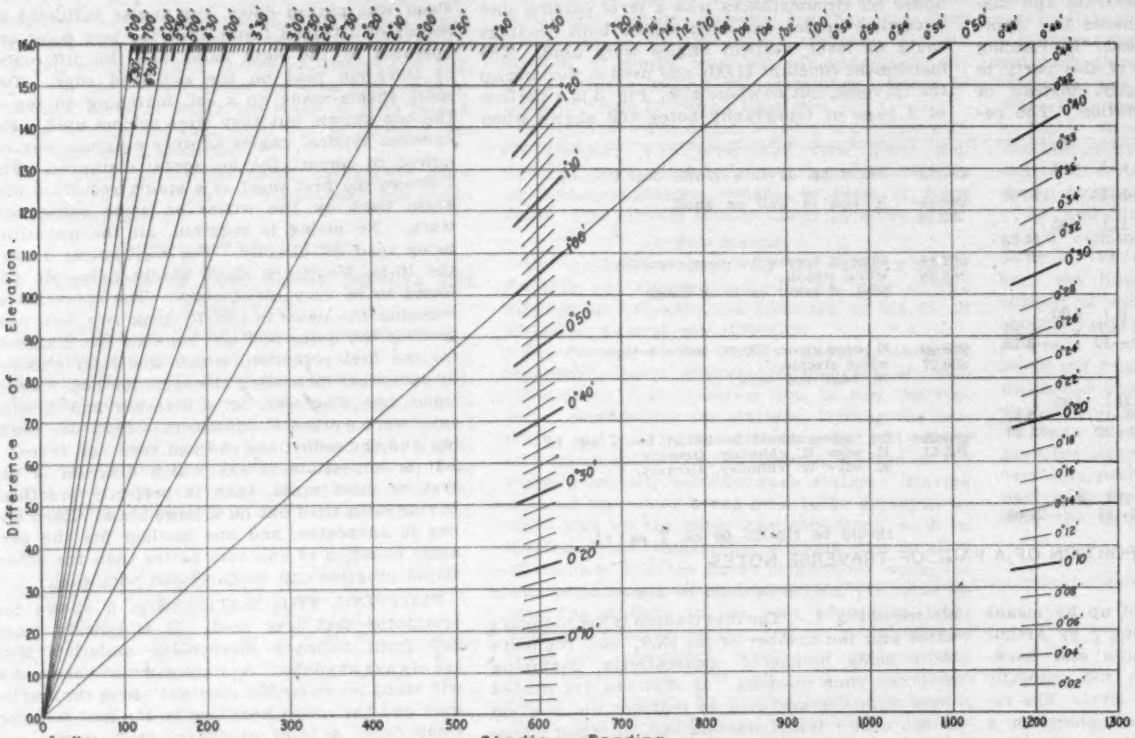

FIG. 6. DIAGRAM FOR READING DIFFERENCES OF ELEVATION FROM STADIA NOTES.

Details and Itemized Cost of Each Survey.

DEENS BRIDGE DAM SITE.—The area surveyed was approximately square, 3,000 ft. on a side, and contained 213 acres. The slopes were not precipitous nor very irregular; the elevation ranged from 200 to 400 ft. The river, 40 ft. wide and 5 ft. deep, ran through the center with only one means of crossing, and that at the upper end of the site. Ten per cent. of the area was wooded, but there were no leaves. The survey was made in March and the ground was bare. The weather was the regulation March type; no time was lost, however, on that account. The topography was taken for 2-ft. contours. Shots were taken not over 20 paces apart and the limiting length was 500 ft. Five traverses were run, aggregating 17,900 ft., with 27 courses; 2,392 shots were taken. The elevations were taken from two benches previously established in the bottom. The party came and went on the train, arriving on the job at 8.30 and leaving at 4.30. Seven and one-half days were spent on the survey, which includes two Saturday half days (Saturdays are counted as whole days, although work ceased at noon). At various times, when things were running smoothly, the head of the party kept the time of the shots, two records reading as follows:

10:30	25 shots	66 shots in 24 minutes or 2.7 shots per minute.
10:37	25 shots	
10:47	16 shots	
10:54	66 shots	Includes 1 move and set up.
11:35		
3:28	25 shots.	
3:35	25 shots.	
3:47	45 shots	Includes 1 move and set up.
4:20	17 shots.	
4:26		

67 shots in 25 minutes or 2.7 shots per minute.

These did not represent bursts of speed and

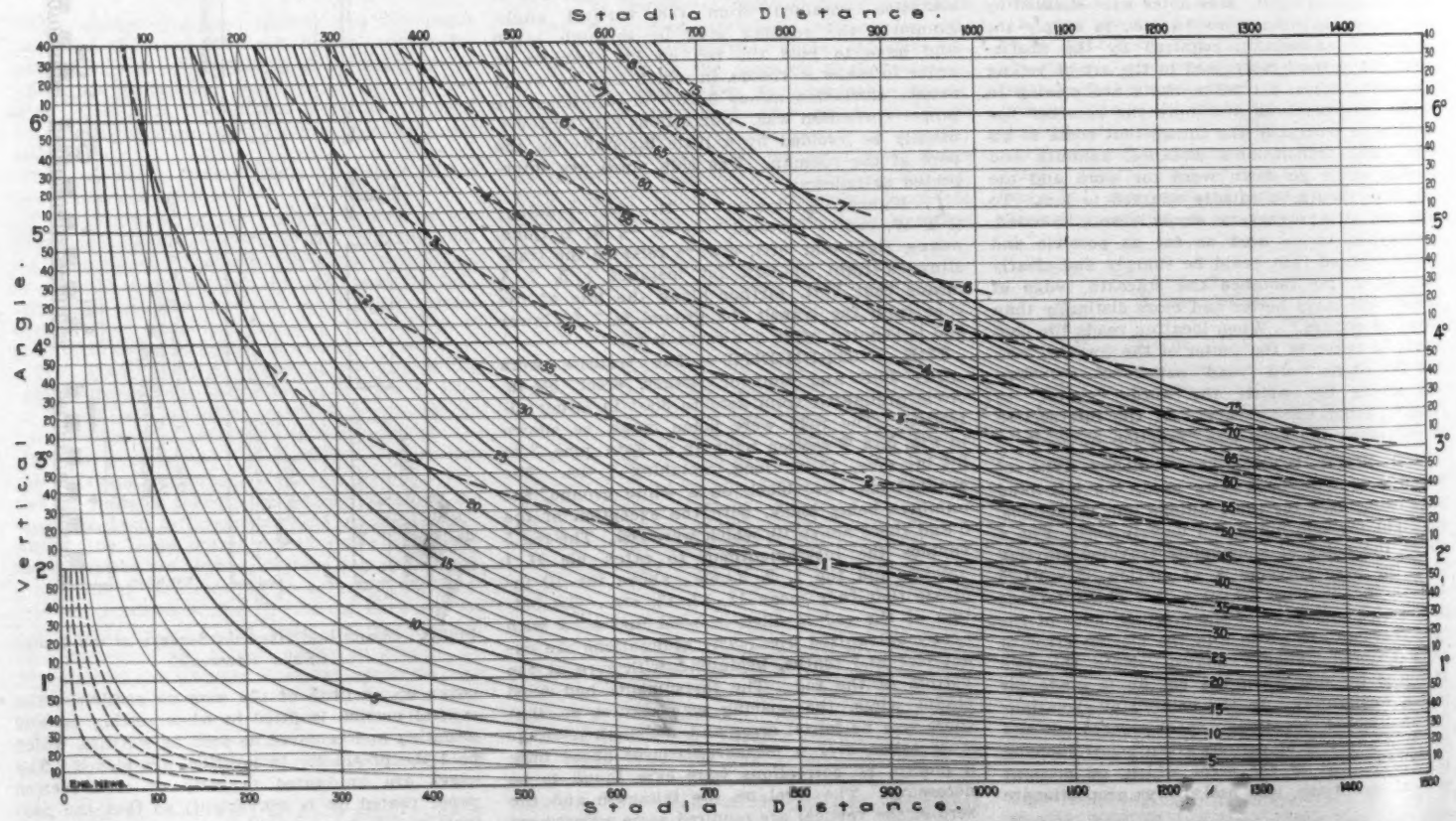

FIG. 7. DIAGRAM FOR REDUCING STADIA READINGS TO DISTANCE.

were often duplicated. The rate for continuous running over average country, including moving and setting up, was 1.3 shots per minute.

The cost of this survey is given below:

1 assistant engineer at	$5.80	per day
1 transitman at	3.80	per day
3 rodmen at $2.90 each	8.70	per day
1 axeman at	2.30	per day
Cost of party	$20.60	per day
Cost of party 7½ days at $20.60	$154.50	
Cost of establishing benches (total cost)	10.60	
Cost of establishing control (¼ of total cost)	6.40	
Total without transportation	171.50	
Transportation by train	9.60	
Total, including transportation	$181.10	

THE HEMLOCK DAM SITE.—This area approximately square, 1,600 ft. on a side, contained 51 acres. One side of the valley was very steep,

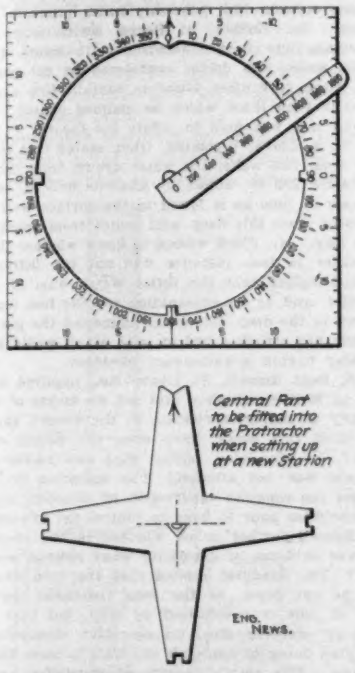

Fig. 8. Protractor for Plotting Stadia Notes.
(14-in. Paper Protractor K. & E. No. 1295.)

rocky and heavily wooded with hemlocks, the other side cleared and with easy slopes. Thirty per cent. of the area was wooded. The elevations ranged from 200 to 350 ft. The river was frozen over. The survey was made in February, with the ground covered with badly drifted snow, nowhere less than 2 ft. deep. The weather was very cold and extremely windy; in fact all the conditions were about as bad as is conceivable. Topography was taken for 2-ft. contours, maximum length of shot 500 ft., and no shots to be over 20 paces apart. Two rods were used, except when the engineer in charge ran a third in order to keep warm. The stadia traverses on the steep side hill in the woods did not check out at all well, and two days were occupied chaining the distances and leveling over the stations. The party drove to the work in a team and put in 5½ hours a day in the field. No axeman was used on this survey. For traverses 25 courses were run, aggregating 8,600 ft.; 1,010 shots were taken. A total of 12 days was spent, 8 actual working days (including one Saturday) and four lost on account of stormy weather; of the eight, two were used up going over traverses a second time.

Cost of party 8 days at $18.30	$146.40
Cost of establishing benches (total cost)	2.50
Cost of establishing control (¼ total cost)	1.50
Total without transportation	$150.40
Team 8 days at $5	40.00
Total, including transportation	$190.40

THE LOWER PORTION OF THE BASIN.—This area, 1,310 acres, comprised the wide and deep portion of the valley between the Deens Bridge dam site and the Hemlock site, about 2 miles long and 1 mile wide, and a long narrow arm about 2¼ miles long and ¼-mile wide extending up the East Branch of the Croton to Deens Corners. The village of Croton Falls lay in the area. About 10% was wooded. The survey was made in April. Topography was taken for 5-ft. contours. Shots were taken about 30 paces apart and the traverses were laid out so that the maximum length of shot was 1,200 ft., three rods were used. The party drove to and from the work, the round trip averaging about 40 minutes per day.

Elapsed time (excluding Sundays)	20 days
2 Saturdays (half-days) and two whole days on other work	4 days
Days on the survey	16

This included two Saturday half-days and three days on which some time was lost on account of rain.

Fifty-two thousand three hundred and fifty feet of traverse were run, composed of 62 courses, and 3,215 shots taken. On 9 days of this survey the head of the party carried a pedometer and, as he usually accompanied the rodmen, the record, which is given below, shows the *minimum* number of miles that they traveled. These were days for fairly open country:

April 10—8.9 miles, 7 hours (all on topography).
" 11—rain.
" 12—13.0 miles, 7½ hours (2½ on traverses and 5 on topography).
" 13—12.2 miles, 6 hours (3 on traverses and 3 on topography).
" 14—12.8 miles, 7½ hours (2 on traverses and 5½ on topography).
" 15— 4.2 miles, 2½ hours (Sat. half-day—all topog.).
" 17—12.6 miles, 6½ hours (5½ on traverses and 1 on topography).
" 18—other work.
" 19—11.6 miles, 7 hours (all topography).
" 20— 8.8 miles, 5½ hours (topography—rain in p. m.)
" 21—authorized holiday.
" 22—authorized holiday.
" 24—14.4 miles, 7 hours (all topography).

Cost of party 16 days at $20.60	$329.60
Cost of establishing benches (total cost)	65.50
Cost of establishing control (¼ total cost)	39.30
Total without transportation	$434.40
Team 16 days at $5	80.00
Total, including transportation	$514.40

THE PORTION OF THE WEST BRANCH.—This area, 200 acres, lay on both sides of the West Branch of the Croton and was about 1¾ miles long, 3,000 ft. wide at the lower end and running to a point at the upper. The slopes were easy, the country open and the river impassable, save at the two extremities of the area. The survey was made in March and good weather prevailed. Topography was taken for 5-ft. contours, using party and methods previously described. Two teams were required to transport the party, the roads being in very poor condition, as the frost was coming out of the ground. Three traverses were run aggregating 10,520 ft.,

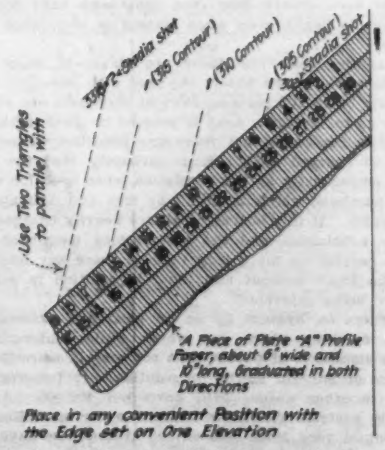
330'-2-Stadia shot
(305 Contour)
(310 Contour)
(305 Contour)
300'-Stadia shot
Use Two Triangles to parallel with
"A Piece of Plate "A" Profile Paper, about 6" wide and 10" long, Graduated in both Directions
Place in any convenient Position with the Edge set on One Elevation

Fig. 9. A Device for Interpolating Contours.

with 16 courses. Three complete days were spent on the survey, and 781 shots were taken.

Cost of party 3 days at $20.60	$61.80
Cost of establishing benches (total cost)	10.00
Cost of establishing control (¾ total cost)	6.00
Total, without transportation	$77.80
Transportation 3 days at $10	30.00
Total, including transportation	$107.80

SUMMARY OF COSTS.—The data given for the four surveys are here summarized for convenient comparison.

	Detail topography		Topography for 5-ft. contours.	
	Deens Bridge.	The Hemlocks site.	Lower end of basin.	West Branch.
Area (acres)	213	51	1,310	200
Number of shots	2,392	1,010	3,215	781
Length of traverse (feet)	17,900	8,600	52,350	10,520
Number of traverses	5	...	...	3
Number of courses	27	25	62	16
Days worked (Sat. counts as full day)	7½	8	16	3
Total cost, excluding transportation	$171.50	$150.40	$434.40	$77.80
Total cost, including transportation	$181.10	$190.40	$514.40	$107.80
Acres surveyed per day	29	6	82	67
Shots per acre	11	20	2.4	3.9
Feet of traverse per acre	84	168	40	52
Cost per acre, excluding transportation	$0.81	$2.94	$0.33	$0.39
Cost per acre, including transportation	$0.85	$3.74	$0.39	$0.54

Summary.

The four surveys detailed above represent work done under uniform conditions in each case and the costs include the most important items. No attempt has been made to include a percentage for instruments, office rent, fuel, lighting, equipment, expense accounts and the like, such allowances properly belonging to the grand total for the complete reservoir survey. The surveys are given in considerable detail so that any one can intelligently adapt them to his particular conditions of country, salaries or traveling expenses. The most difficult part to analyze is the method of conducting the work, which has a most important bearing on both the rate of progress and the cost. But rapid progress is not the only object to be obtained, although it is frequently allowed to overshadow everything else. If the plotting discloses areas not covered, contradictory data, important objects not located or notes impossible to plot on account of insufficient side notes or sketches, the large number of pages of notes turned in each night can reflect no credit to the party and the cost, when the expense of going over old work in the field is added in, jumps up at an amazing rate.

Is Softened Water a Desirable Municipal Supply? Experience at McKeesport, Pa.*

By A. G. SANDBLAD,† M. D.

Scarcely had the McKeesport water-softening and filtration plant been in operation four weeks, before a certain professional man of that city declared "that any one who drinks the McKeesport softened water for two years will be dead." Kindly note that these words did not come from a layman. They cannot be swept aside without further comment as the immature conclusions of an untrained mind. Coming as they do from a man of mature years, wide experience, and supposedly mature judgment—a member of a profession whose calling it is to preserve human health and happiness, they demand the attention of water-works men, and it is the object of this paper to ascertain if such conclusions have any foundation in facts.

This is an extreme and drastic declaration, in which few persons will concur; but many persons, who are not acquainted with the methods of water softening, sometimes entertain some doubts in their minds as to the entire wholesomeness of a softened water supply. That water is softened successfully for boiler purposes no one will deny. But that water intended for domestic use can be softened by chemical processes and leave no injurious matter in the water seems beyond the possible to many, even those who should, by their training and experience, be in a position to form an accurate opinion on the question. Many of these doubting Thomases are honest and intelligent persons. They are honest in their apprehensions and they are willing to accept reasons if they have them presented to them in a manner which they can comprehend.

Of course I am aware that not all those who object to the softening of municipal supplies are in this class; there are some who raise objections because they have prejudices and refuse to accept reasons. It is self evident that to reason with this last class is a waste of valuable time, as no argument that can be adduced in favor of water softening will influence them one iota.

The rank and file of the public, however, are willing to accept sound reason as to the harmlessness of the processes in vogue for softening water, and will then cast all doubt aside as to the desirability of a softened municipal water supply. When the facts are thus set

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forth and become thoroughly understood by the public, it is not unusual to find that persons who looked upon the scheme with distrust, become the staunchest friends of water softening as a preliminary to filtration.

The labor of enlightening the public upon the matter is well worth the trouble, as for every such friend that is gained for a purer water supply the labors of city water departments and councils are made less difficult, and the necessary means for carrying on the work are more willingly granted. Very often the objectors, like the one quoted at the beginning of this paper, do not state any specific reasons for their adverse conclusions, but, on the contrary, demand to be believed on account of their standing in the community, or on account of professional relations. Professional relations have a great deal of influence with the public at large, a circumstance which is very often sadly abused. But no professional relations alone should bear weight in establishing an opinion unless that opinion is shown to have a sound scientific basis. This applies to all questions alike and to the advocates of water softening as well as to their opponents.

It is necessary, therefore, that as advocates of a higher purity standard of municipal water supplies, if we are to gain the public confidence, shall give the people full and acceptable reasons for any procedure which we may expect the public to accept. With the sanitary quality of softened water in view, I will now try to set forth briefly the principal methods of water softening, what is accomplished by it, what products if any are left in the water, and what effect such products may have upon the animal economy.

It goes without saying that one answer will not, and cannot, cover all conditions. However, by classifying the conditions as generally found, we find two very different conditions of hardness requiring softening of water. In the first place, waters may possess temporary hardness only, due to calcium and magnesium carbonates being held in solution by the presence of free carbon dioxide. We have also at the second instance, waters whose hardness is due to the presence of soluble sulphates of lime and magnesia. As a subdivision of this second class we have waters which are contaminated with metallic salts and free mineral acids. Of this latter type is the source of supply of the city of McKeesport.

Of course no one should undertake to select a system of softening for any given locality without first becoming thoroughly acquainted with all the varying conditions and peculiarities of that locality's source of supply. Only a thorough knowledge of such data can result in a successfully designed plant; therefore no one should decide until all the conditions have been ascertained over a sufficiently long period of time to warrant definite conclusions. No definite time can be arbitrarily laid down. It may require months in one locality, and it may require years in another for the gathering of sufficient data.

Waters of the first mentioned class, possessing temporary hardness due to the presence of carbonates of lime and magnesia, rendered soluble by free carbon dioxide, are very successfully softened by the addition of carefully regulated quantities of lime water, or milk of lime. The reaction that takes place is very simple, and consists of an immediate union between the added lime and the free carbon dioxide. The water is robbed of its lime solvent properties, the calcium carbonate is almost completely insoluble, and the water is softened. This process of softening was first invented by Dr. Clarke, of England. This method is, however, entirely useless with waters of high permanent hardness, due to calcium sulphates, and only partially successful with waters of combined magnesian and calcium hardness. In softening by this process no product of the softening remains in the softened water, as the calcium carbonate formed in the reaction is insoluble and comes down with the rest of the precipitate.

Waters possessing permanent hardness, as well as those waters which are being contaminated with mine and factory refuse, and therefore hold metallic salts and free sulphuric acid in solution, may be given the lime treatment. This frees the water from acid and forms insoluble metallic hydroxides with the metallic salts, but increases the hardness by the additional gypsum formed, requiring the addition of soda carbonate. This, in its turn, reacts with the gypsum and by double decomposition forms insoluble calcium carbonate with the lime of the gypsum, and soluble sodium sulphate which remains in solution in the finished product. We see at once that in this process there is left in the water a new product, a case which is impossible with the process for removing temporary hardness previously described. This product is, however, entirely harmless and exists in considerable quantities in almost all natural waters, of known purity and acknowledged healthfulness.

This latter process of softening is the one used in the McKeesport plant, which has now been in successful operation for one year. The bad conditions of the Youghiogheny River are so notorious as to require little if any comment. A little over a year ago the published report of the U. S. Geological Survey classed it as "the worst in the country." Such a sweeping statement does not give much of an idea of the conditions which require changing, in order to make this "sewage drain," as another expression has designated the stream, yield a clear and wholesome drinking water. Therefore, I will state briefly that the stream is contaminated with mine and factory effluent, which renders the water very acid. From the same sources it carries always more or less iron and aluminum sulphates in solution. The water has no temporary hardness, except for brief periods following heavy rainfalls over the watersheds. During such periods the acidity disappears for possibly a few hours. These periods are so brief that they may be considered a negligible quantity. In addition to the above content there is a small quantity of carbon dioxide present, but this may even be considered negligible.

Numerous weekly tests of the raw and filtered water, during the various stages of the river, have shown that the total solids in solution in the raw water varies between wide limits. The lowest find has been seven parts and the highest 110 parts per 100,000. The general average is not far from 14 parts. The filtered water has yielded about 9% less. This shows very clearly that the softening process does not tend to leave in the water a great deal of the chemicals used, as is claimed by ignorant critics.

The process of softening at the McKeesport plant is the well-known Porter-Clark, which has now stood the test for over a half century and is the only process which has been thoroughly successful with this class of waters. The chemicals used in this process are lime of the highest obtainable purity, and anhydrous soda ash, or soda carbonate.

The lime when slaked forms calcium hydroxide, a powerful alkali and an antacid. This is added to the water as a milk of lime and gives fully saturated lime water. It converts the metallic sulphates in the raw water into insoluble metallic hydroxides; this includes also the magnesia, the most insoluble form of which is the hydroxide. The free and combined sulphuric acid is converted into the sulphates of calcium, otherwise known as gypsum. A few minutes after the reaction is completed the water is treated with a solution of the soda ash, which, as explained above, precipitates the lime in the gypsum as insoluble calcium carbonate, also forming soluble sodium sulphate, which remain in the finished product.

The water is thus freed from all the salts of the heavy metals, also of its gypsum; it has an alkaline reaction and cannot hold more than three parts of calcium carbonate in solution, or of magnesia about 2.4 parts; in other words, the water is softened down to about a hardness of 6 parts per 100,000 or less. Of course, in actual work this is not always obtainable with Youghiogheny water, owing to the extreme and sudden fluctuations of the conditions of the river. Therefore, the average hardness of the city supply is a little higher than the figure given, but the result is a very acceptable water.

Now to the sanitary question again. Is there any thing of an injurious nature left in the water which has passed through this process? Show me the well or spring water which contains less of these very same substances. All waters contain them, not only in the small amounts mentioned, but many times this amount. Besides it has never been proven that even lime salts have been injurious to health even when present in very large quantities.

Statistics show that there are places in many parts of the world where waters are used with impunity, which contain 90 to 100 parts of calcium carbonate per 100,000. Now as to the soda, none is present in the finished product as carbonate, but there are localities where wells are so charged with sodium carbonate that the water acts prejudicially on the vegetation when used for watering purposes, yet it is drunk by men and animals with impunity. If this is true of waters heavily charged with these substances—and the observations mentioned have been carried on for a long time—is there any likelihood of the small amount remaining in solution in softened water being injurious?

Writers on hygiene fix as an ideal and exceptionally good drinking water one which while conforming to other standards of purity, does not contain more than 20 grains of mineral matter in solution, per Imperial gallon; in other words, 28.57 parts per 100,000. As our weekly analysis shows the softened water at McKeesport to contain very much less on the average, we have very good reasons to conclude that water softening is making a very desirable municipal water supply.

The advantages obtained are in the saving of soap, preserving of clothes in the laundry, better results in cooking, etc. There is great diminution in the albuminoid ammonia in the filtered and treated water, which may at times amount to total disappearance of the albuminoid ammonia.

At McKeesport very nearly all bacteria disappear in the process of settling. This result may be peculiar to our water as the excess of metallic salts give a precipitate of hydroxides of alumina and iron which are heavy enough to settle rapidly and are gelatinous enough to entangle the suspended matter, including the bacteria. This makes the filtering easier and the time between the washings of the filter-beds longer. This means also a considerable saving on the wash water.

If by these simple remarks I shall have created some little interest in the softening of municipal supplies and if thereby the confidence in the process has been somewhat promoted, my labors have been amply rewarded.

There was a long discussion on this paper, the remarks turning largely on incrustations in pipes and on apparatus. A few questions, however, were asked closely relating to the subject of the paper and these are recorded below.

It was asked "what proportions of lime in water would be considered as unfitting it for domestic use?"

The reply was that if calcium carbonate was referred to there was no given amount of lime in solution that will make a water necessarily injurious for drinking purposes. The quality of hardness makes the water unfit for laundry and cooking purposes when the hardness exceeds 15 parts per 100,000. The author said that it has been claimed that lime-salt water produces certain diseases. Dr. Kocher, of Berne, Switzerland, claims that certain lime charged waters were the cause of goitre. But the wells, this doctor considered as not producing goitre, were very often found to contain 40% more calcium salts than those which he claimed caused the disease and this was held to refute his theory.

Mr. W. A. Clark, Wyoming, Ohio, stated that in water drawn from two wells, the water drawn from the lower depth, some 200 ft., shows by analysis only ½ as much carbonate of lime as is found in the surface well water. The water from this deep well comes from below 60 ft. of blue clay. Mr. Clark wished to know whether the deep well water in this instance was not the better? Dr. Sandblad replied that the softer water was, of course, the better, and as an explanation for the less degree of hardness in the deep well water suggested the possibility that they had struck a bed of soda which would prevent the water having a permanent hardness.

Mr. S. Bent Russell, St. Louis, Mo., inquired whether or not at McKeesport they ever get an excess of caustic alkalinity or sodium carbonate in the water; and if so what effect this would have upon the health of consumers? Dr. Sandblad replied that any excess of the chemicals was not allowed. The softening is carried on under the constant supervision of chemists and tests are made from hour to hour to control the process.

Mr. Russell further asked whether in the event that there was evidence of causticity what remedy would be applied? Dr. Sandblad replied that the lime treatment would be cut down, or the soda treatment increased. Excess of lime is neutralized by soda, but that would be a poor economy from an operative standpoint, the better plan being to diminish the lime to meet the soda treatment. The small amount of causticity resulting would hardly have any effect unless in the extreme case of a reckless operator.

Mr. A. M. Fisher, of Coshocton, Ohio, inquired whether the softening of the water did not greatly lessen the necessity of soap and the use of boiler compounds? To which Dr. Sandblad replied in the affirmative, and that the saving of soap would more than pay for the chemicals; that the taxpayer is better off in paying for results in the shape of water softening than in form of soap. This was corroborated by a member present, who held stock in a steam laundry in McKeesport.

Portable Machines for Making Asphaltic Concrete Paving.

Asphaltic-concrete paving of a special type, known as mineral-rubber paving (and described elsewhere in this issue), is being used on an extensive scale by the South Park Commission, Chicago. Some of the work is done by contract, while a large amount is done by the Commission on the day labor system. In this latter part of the work, portable machines are used for making the asphaltic composition which forms the wearing surface, thus avoiding the objectionable features of installing a semi-permanent plant in a park or residential district, with the long haul of the material from such a plant to the work. By the use of the portable machines, also, the preparation and laying of the paving may be operated under one organization and under the direct supervision of one superintendent and inspector.

These machines were invented and patented jointly by Mr. Linn White, Chief Engineer, and Mr. H. S. Richards, Assistant Superintendent, of the South Park Commission. The first machines, which were used during the season of 1908, proved unsatisfactory in some respects, and two machines of an improved design were built to the inventor's plans by the Link Belt Co., of Chicago. These have been in regular use since June, 1909, and it is expected that they will have made ma-

terial for over 150,000 sq. yds. of paving by the end of the season. A smaller machine is also built, and will be used more particularly for repair work. The machines are to be built by the above company for sale or lease to contractors and municipalities.

The larger type of the machine is shown in Fig. 1. It is about 27 ft. long over all and weighs about 16 tons. It is mounted on broad-tired wheels, and as the paving advances the machine is moved readily (about 300 ft. at a time) by one of the road rollers used on the work, or by the gasoline traction engine which furnishes the power; driving the main shaft of the machine by means of a belt. Fig. 2 shows two of the machines at work, and beyond the first one is the gasoline traction engine mentioned above. The men at the left are delivering the sand and stone upon a pile from which it is shoveled into the heating drum. At the other end, the man with the lever is opening the gate to discharge a batch of the mixture into the wheelbarrow held by the stooping man.

The equipment mounted on the steel frame of the machine includes a heating furnace, a revolving drum which serves as a drier and mixer

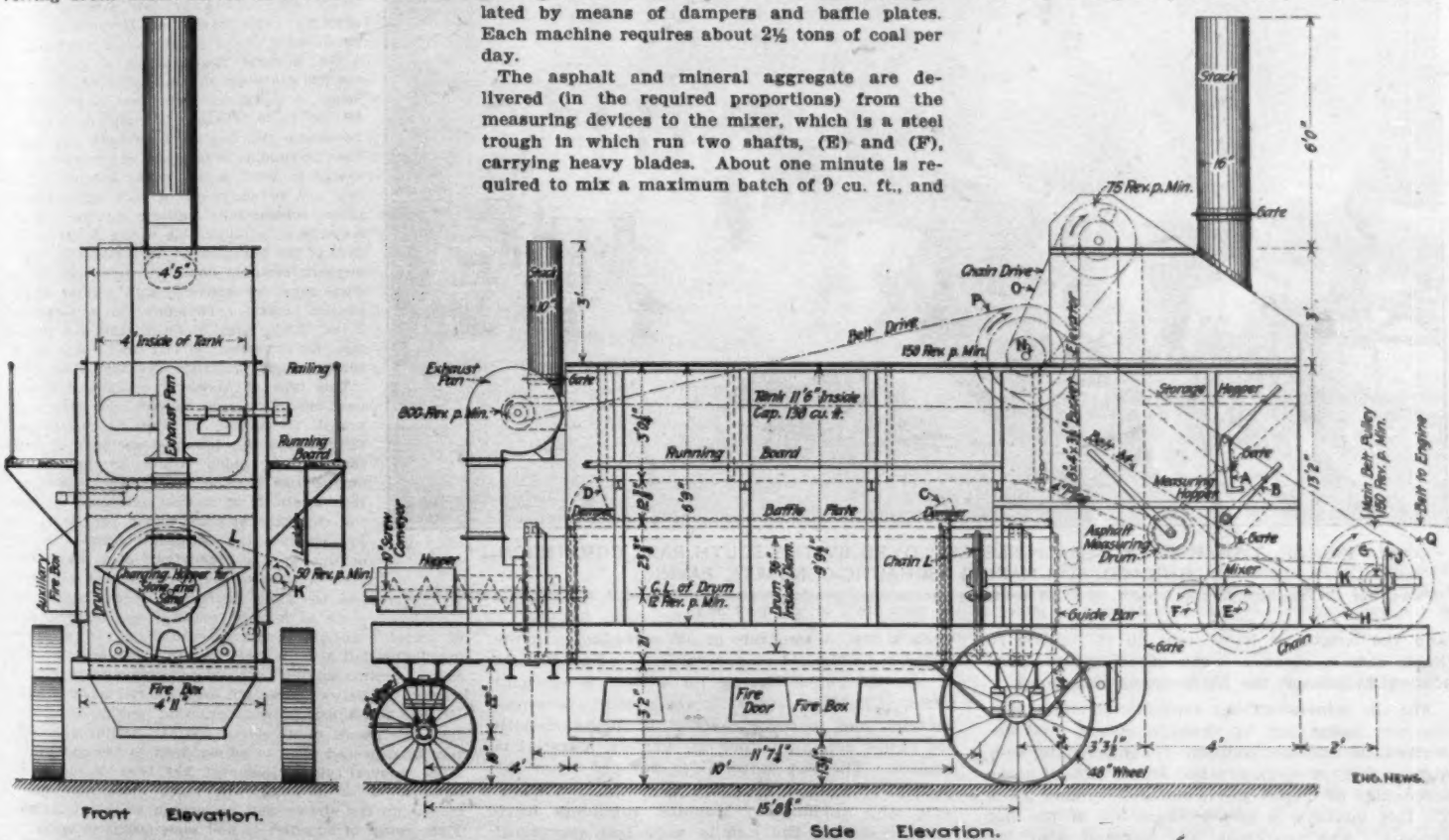

FIG. 1 PORTABLE MACHINE FOR MAKING ASPHALTIC-CONCRETE PAVING MATERIAL.

for the aggregate, an elevator and bin for the hot aggregate, a melting tank for the asphalt, measuring devices for the asphalt and aggregate, and a mixer from which the finished mixture is discharged as required. The stone and sand (in proper proportions) are dumped in a pile in front of the machine and shoveled together into a hopper from which the material is fed by a spiral conveyor to a horizontal revolving drum 12 ft. long, which is placed directly over the furnace, and in which the material is heated to about 300° F. Inside of this are wings and scrapers which thoroughly mix the materials as they pass forward slowly, the drum revolving at about 12 r. p. m. From the end of the drum, the mixed aggregate drops into the boot of a bucket elevator which delivers it to a storage hopper at the top of the machine. From this it is fed by gravity to the measuring hopper, ready to be delivered to the mixer simultaneously with the asphalt. When the gate of the storage hopper is open, the arm (A) on the operating lever engages with a pin (B) on the lever which operates the gate of the measuring hopper, so that the two gates cannot be opened at the same time.

Along the top of the machine is an asphalt melting tank. The asphalt, which needs no fluxing, is charged at the end where the heat is greatest, and is drawn from the other end to the measuring device. About 3½ tons of asphalt can be put in the tank at once and maintained at the desired temperature (according to the grade of material used). Material is added as needed. By means of automatic measuring devices any desired amount or proportion of asphalt or aggregate can be delivered to the mixer. The coal fire for heating the materials is beneath the main part of the machine. The products of combustion rise around the drum and from this pass beneath the asphalt tank. A fan then sends the hot gases through the interior of the drum and around the storage tank and measuring box, and they escape finally by a smokestack at the rear. When the materials do not require to be heated, the damper (C) is closed and damper (D) opened, allowing the heated gases to pass directly to a smokestack at the front end of the machine. It is to be noted that the asphalt does not enter the drum, which is directly over the fire where it might be overheated. The amount of heat passing beneath the asphalt tank can be regulated by means of dampers and baffle plates. Each machine requires about 2½ tons of coal per day.

The asphalt and mineral aggregate are delivered (in the required proportions) from the measuring devices to the mixer, which is a steel trough in which run two shafts, (E) and (F), carrying heavy blades. About one minute is required to mix a maximum batch of 9 cu. ft., and the finished mixture is then discharged through a bottom sliding door into wheelbarrows or steel hand carts to be conveyed to the work. The temperature of the finished mixture is about 275° F.

At the rear of the machine is a transverse main shaft (G) with a pulley for the chain (H) which drives one of the mixer shafts, the two shafts of the mixer being connected by gearing. The main shaft has also a bevel gear drive (J) for the shaft (K) which drives the heating drum by means of the chain (L). A belt (M) from the main shaft drives the countershaft (N), which has a driving chain (O) for the bucket elevator, and a belt (P) for the exhaust fan.

The machine is driven by an independent engine, as already noted, for it would be too heavy and cumbersome if equipped with its own engine and propelling equipment. On the work of the South Park Commission the power is furnished by a 20-HP. horizontal gasoline engine mounted on a wheeled frame equipped with propelling gear, the outfit forming a gasoline traction engine as built for agricultural and construction work. A belt connects the engine pulley with the pulley (Q) on the main shaft of the machine. In moving, the belt is unshipped from the engine pulley and carried by several men. The machine can be disconnected, moved 300 ft., have the belt readjusted, and be started up again in a very few minutes.

Each plant has an average capacity of material sufficient for 1,000 sq. yds. of 2-in. paving per 9-hour day, but can turn out material for 1,250 sq. yds. under specially favorable conditions. It is expected that over 150,000 sq. yds. of paving will be made by these machines before the close of the present season. The cost of paving made in this way is very reasonable, and is said to be considerably lower than any bids for contract work. For the first piece of work (about 60,000 sq. yds.), the cost was estimated at 75 cts. per sq. yd., but was actually done at a cost somewhat lower than this. This included the mixing and laying of the material, the grading and surfacing of the old macadam which forms the base, and resetting some concrete curbing, together with the labor cost and machinery repairs.

These portable machines serve to expedite the work by acting as pace-makers; they must be kept in continual use, which means that all the processes of feeding, discharging, conveying and laying must progress steadily, so that there is little opportunity for loafing on the work. This feature does not exist, at least to the same extent, where mixing machines are at a distance from the work, so that the delivery of the material may be delayed. As the machines are moved at short intervals, the smoke does not constitute a serious objection, even in residence districts. The machines might be adapted to the use of oil fuel, but as this gives an intense and concentrated heat, firebrick arches would have to be used to prevent local overheating of the drum or burning of the mixture.

Both machines are employed on the same piece of work (as shown in Fig. 2) under the general direction of one foreman. The complete working force for each machine is about as follows:

1 fireman.

1 leverman regulating the measured supply to the mixer.

1 dump man operating the door of the discharge hopper.

1 repair man or attendant (he usually attends to the inspection, oiling, etc., of both machines).

1 tank man in charge of the melting (he also usually attends to both machines).

1 engineman for the portable gasoline engine which furnishes the power.

5 to 7 men shoveling aggregate into the hopper of the drum.

5 to 7 men wheeling the mixture to the work.

For handling the material on the above work, hand dump-carts or wheeled tubs of 5 cu. ft. capacity are found to be more convenient than wheelbarrows, besides enabling work to be done at a higher speed. The average load is 3 cu. ft., and the length of haul from 50 ft. to 300 ft. Each cart is given a wash of oil before being loaded, to prevent the charge from sticking.

For the mineral-rubber asphaltic-concrete paving now being laid by these machines (and described in another column) the aggregate consists of 60% of ½-in. crushed stone, 20% of stone screenings or coarse sand, and 20% of fine sand. To this mixture is added about 9% of the hot asphalt. The machines are adapted also for laying sand-aggregate sheet-asphalt paving, and for the use of tar or other bituminous material when desired.

FIG. 2. TWO PORTABLE MACHINES EMPLOYED BY THE SOUTH PARK COMMISSION, CHICAGO, FOR MAKING ASPHALTIC-CONCRETE PAVING.

(Power for the machine in the foreground is furnished by the gasoline traction engine just beyond it, the engine pulley being belted to a pulley on the main shaft of the machine.)

Asphaltic-Concrete Paving in Chicago.

The desirability of providing residence streets and park drives with an economical paving that will resist wear and be free from dust under severe conditions of traffic (especially where automobiles form a large proportion of the traffic), and which will be practically noiseless, has led the South Park Commission, of Chicago, to undertake extensive experiments with special paving materials and special treatments of the pavement. These experiments have been carried out on the streets, boulevards and park driveways under the jurisdiction of the commission. They have included (1) the treatment of macadam paving with different compositions for the purpose of preventing dust and disintegration, and (2) the use of an asphaltic-concrete wearing surface of different kinds. The first of these methods has proved inadequate where the traffic is heavy and includes a large proportion of automobiles.

As the result of experiments extending over two years, the commission is now making extensive use of an asphaltic-concrete paving which has been given the name of "mineral rubber" in order to imply its noiseless, elastic and durable qualities. It is not patented, but it requires the use of a special grade of asphaltic cement, and on the work done by the commission on the day-labor system with its own forces a patented portable machine is used for preparing the mixture. This machine is described elsewhere in this issue.

The material is a mixture of stone (of uniform size) and sand with hot asphalt, and is laid in much the same way as sheet asphalt. It is used as a wearing surface 1 in. to 2 ins. thick, laid upon a base of concrete or old macadam. In the latter case, the old surface is loosened by the use of a road roller having its wheels fitted with picks; it is then dressed to the proper grade and contour, and in some cases it is sprinkled with hot liquid asphalt before the surface material is applied. The hot material is dumped upon the foundation and spread with rakes to the proper form and thickness. Machine spreaders have been tried, but the results were less successful than the ordinary hand raking.

The material is then rolled with a 10-ton steam roller. It is "lively" under the roller, having a liver-like motion which shows its elasticity. It is not so hard but that heavy wheels and the calks of horseshoes will indent it, but these marks iron out under traffic. The permanent rubbery quality (combining smoothness and toughness) due to the asphaltic cement is considered to give the material an advantage over bituminous concrete made with tar compositions, the tar being liable to make the paving too soft in summer (resulting in permanent ruts) and brittle in winter (resulting in disintegration).

In some of the work, the paving was laid in sections extending across the street, the asphaltic-concrete being laid against wooden strips, as in laying ordinary concrete. It was found, however, that the transverse joints showed permanently, and the material did not bond. In present practice, therefore, the material is laid as a continuous unbroken sheet.

The following description of the paving construction is taken from a paper which was prepared some time ago for the American Society of Municipal Improvements by Mr. Linn White, Engineer for the South Park Commission, but which has since been revised by him for our use.

The mineral-rubber pavement is elastic, noiseless, dustless, non-slippery and impervious to water. It has also permanency and strength. However, it is obvious that no pavement can be so permanent and strong that it will sustain the heaviest loads indefinitely and never wear out, nor can it be so perfectly "rubbery" in character that the blows of a horse's hoofs will not produce some noise. Other requisites of the ideal pavement include moderate cost, ease of repair, a smooth sanitary surface, and an agreeable dark color free from glare. The materials of which it is composed must be plentiful and easily obtained. The machinery for its preparation must be simple, and the labor needed should not require high training. These conditions, however, are implied when we say it must be moderate in cost. Uniform consistency under a wide range of temperature is implied under permanency, but is so important that it should be emphasized.

The pavement may be defined as an asphaltic-concrete wearing surface, resting upon a base composed of cement concrete, macadam, bonded gravel, bituminous composition, or any other permanent and stable foundation. The asphaltic cement, to give the rubbery qualities desired, must be comparatively soft, of rather low melting point, showing great range of temperature and permanency under extremes of exposure.

The mineral aggregate is a mixture of crushed stone (or gravel) and sand, the sand being in sufficient proportion to practically fill the voids between the particles of stone. To secure the maximum strength and wear, the maximum proportion of coarse stone should be used in the paving mixture. This can best be accomplished with one grade of stone, substantially uniform in size, and as large as it is practicable to use in the thickness of the pavement.* To secure the elastic support desired, however, each particle of stone must be cushioned with a layer of asphaltic cement. Therefore, in a pavement 2 ins. thick, ¾-in. stone is about the proper size; for pavements of less thickness stone of correspondingly smaller size should be used.

This type of pavement occupies a middle position as to cost between the very high priced pavements of the expensive city streets, and the low cost methods of road construction which aspire to be classed among the so-called permanent pavements. It is elastic in more than one sense, because the character of construction can be varied by making the wearing surface thicker or thinner, the foundations of a heavy concrete or a more cheaply constructed macadam, and the stone aggregate of such a grade of stone as may be required by the conditions of travel. An old macadam road forms an excellent foundation if it is made free from dust or mud and has a coarse, grainy surface. The wearing surface, having a stability of its own, does not creep or roll under traffic. If the foundation proves somewhat weak, the pavement (by reason of its elastic and self-healing qualities) may be depended upon to adjust itself to the conditions.

The mineral-rubber pavement has been developed in Chicago. It is an outgrowth of the conditions which existed on the streets and boulevards of that city, and is the result of an effort to find some means of bettering the driveway surfaces without excessive cost. The principal boulevards of Chicago under the control of the South Park Commission carry a large volume of traffic, from which the heaviest teaming is mostly excluded. The boulevards in the downtown district, such as Jackson Boulevard and Michigan Ave. (north of 22d St.) have long been paved with sheet asphalt.

But south of 22d St. and north of Chicago Ave., up to within the last two or three years the best efforts of the park management have been directed to trying to maintain macadam road surfaces. Before the advent of the automobile in such large numbers, and before quite so high a standard of road and street construction had been set up, it was possible to do so. Well crowned and well drained macadam roadways 12 ins. thick, the upper 4 ins. of granite, bonded with limestone screenings or a natural cementitious gravel, were considered the acme of good road construction for driveways from which traffic teaming is excluded.

But about 1905 it had been thoroughly impressed upon the Commission that water-sprinkled macadam roadways could not be maintained in a satisfactory condition with the expenditure of any amount of labor or money. The constant interruption of travel for repairs was one of the difficulties which had developed under existing conditions. In 1905, the South Park Commission took

*In this respect the pavement differs from some bituminous macadam paving in which the stone is of graded sizes in different proportions.—Ed.

the lead in the experiments with various oils and tar preparations as dust layers and road preservatives.*

At first it was thought that if the dust could be allayed, or its formation prevented, the raveling of the macadam would be stopped. Soon it was found that the lighter oil or tar liquids, though reasonably effective in preventing dust, added so little material of a binding quality to the road surface that the raveling continued. It was then realized that to get any lasting results at least the upper layer of macadam must be penetrated and bonded with the preservative material. This led to the use of specially prepared tar compositions and the heavier asphaltic oils which require heat in their application. This kind of treatment has been continued up to the present time with varying and sometimes unsatisfactory results.

The Chicago boulevards and park drives carry a daily traffic of from 500 to 10,000 vehicles per day at different points, and when the traffic exceeds 1,000 to 1,500 per day the best of the surface treatments have been found inadequate. Careful study was then made of various paving materials and processes, with the result that preference was given to some form of bituminous sheet pavement with a crushed stone aggregate: This, of course, included any of the forms of tar-macadam, asphalt-macadam or bitulithic. As a practical expression of the preference for this class of pavement, the South Park Commission contracted in 1907 for about 75,000 sq. yds. of the bitulithic pavement.

In the meantime, studies and experiments were continued in the belief that better results could be got by the use of better binding materials, and more economical results by the use of simpler methods. As a result the first block of what has been termed mineral-rubber asphaltic-concrete pavement in the South Park system was laid on Michigan Ave. in May, 1908. This block was laid with a wearing surface 2 ins. thick on an old macadam base; the base was given a light top dressing of new crushed limestone, and rolled dry without the addition of any binder stone. Subsequently other sections of this pavement were laid on Grand Boulevard, the Lake Shore Drive in Jackson Park, the North Shore Drive, and in Lincoln Park. The confidence felt in its good qualities was fully vindicated by its behavior during the unusually hot summer of 1908, not the slightest defect or sign of movement having been discovered in the surface. All of the above mentioned pieces of pavement were laid on old macadam base. One block (on Grand Boulevard) has a wearing surface only 1 in. thick, but after a year's service it is in perfect condition.

This paving has been laid recently on Michigan Ave., between 12th St. and Jackson Boulevard, where the traffic is extremely heavy (as high as 10,000 vehicles per day). Here the paving is 2 ins. thick (on a 6-in. concrete base), and after being well rolled with 10-ton rollers it is covered with a skim coat of hot liquid asphalt which is spread with rubber "squeegees." This is covered with a thick top dressing of coarse, sharp sand, and the surface again rolled so that a considerable proportion of the sand is forced into the asphalt. The finished pavement is left to set for a day or two before being thrown open to traffic. The excess of sand is gradually removed by street cleaning, leaving a smooth dark rubbery surface with the sand grains embedded in it. This piece of work (covering about 35,000 sq. yds.) has been done for the South Park Commission by contract. The asphaltic-concrete was made in a Hetherington & Berner two-car railway plant located on a siding of the Illinois Central Ry. at the lower end of Grant Park, and the material was hauled to the street in dump wagons.

On the 50,000 sq. yds. of work which is now being done in Washington Park by day labor, the skim coat of liquid asphalt is omitted, and as soon as the 1¾-in. course of asphaltic-concrete is spread on the dressed macadam surface, it is covered with a layer of granite screenings (up to ½-in. size) and is at once rolled. On Michigan Ave., between 29th and 55th Sts., about 60,000 sq. yds. have been laid on an old macadam base and with a top dressing of limestone chips. On Oakwood Boulevard, about 17,000 sq. yds. were laid with a top dressing of limestone chips. All of this work was done by day labor by the Park Commission, and with the use of the portable asphalt machines which are described in another column. The cost of the first work done with these machines was less than 75 cts. per sq. yd.

The details of the construction of this pavement are given by the following abstract of the specifications prepared by Mr. Linn White, Engineer of the South Park Commission.

*Engineering News, Feb. 8 and 22, 1906; Sept. 19, 1907.

Specifications for Mineral Rubber Asphaltic-Concrete Pavement.

FOUNDATION.—If the foundation or base upon which the pavement is laid is of concrete, it may be laid according to any standard specifications for concrete base for bituminous pavements, the thickness being in proportion to traffic to be carried, and the surface made fairly rough and grainy, so that the paving material may get a proper bond or grip.

If the base is to be of macadam, it shall be built as though a macadam wearing surface was intended, except that the upper layer of stone shall not be completely filled and bonded; the intention being (as with the concrete base) to produce a somewhat rough, grainy surface. If the pavement is to be laid on an old macadam base, the surface should be thoroughly swept and cleaned of all fine material that may be either caked upon the surface of the stone or lying loose as dust, thereby exposing the clean stone in the surface for the reception of the paving material.

When it is not practicable to secure a base (either macadam or concrete) with sufficient grain in the surface to give the desired bond or key between the base and the paving material, the adhesion may be increased by lightly sprinkling the base with asphaltic cement before the asphaltic concrete is spread.

An old brick or granite block pavement, if the blocks are well supported and stable, may be used as a base by thoroughly cleaning the old pavement and lightly sprinkling its surface with asphaltic cement.

PAVEMENT.—The pavement proper consists of a layer of mineral-rubber asphaltic-concrete, of a thickness proportioned to the traffic to be carried. The thickness may vary from as much as 2 ins. where the volume of traffic is heavy, to 1 in. (or less) where the traffic is light.

The materials of which the pavement is composed shall be crushed stone or gravel, of a substantially uniform grade as to size, combined with a definite proportion of sand, and thoroughly intermingled with a filling and carrying substance consisting of mineral-rubber asphaltic-cement. The proportions of the various materials will vary somewhat according to the character of the stone and sand available for the work, but shall be approximately as follows: 52% (by weight) of crushed stone (or gravel); 40% of sand, and 8% mineral-rubber asphaltic cement.

After the materials have been chosen (or assembled on the work) the exact proportions may be determined by experiment, the intention being to produce a paving material that, when compressed under the roller, shall form a well filled compact mass, with a somewhat rough, grainy surface without enough sand and asphalt (considered as the mortar constituent) to flush smooth to the surface.

The sand is for the purpose of filling as much as practicable the voids between the particles of stone and reducing the quantity of asphaltic cement required. The asphaltic cement is used to fill the remaining voids, to bind the mineral particles together, and by the elastic support given to each piece of stone to add stability and resiliency to the pavement.

STONE.—The stone shall be a clean crushed stone, either limestone, granite, trap or other stone used for paving purposes, broken as nearly cubical as is practicable. It shall be of a substantially uniform grade as to size; that is, of one grade such as is commercially practicable to produce in an ordinary crushing and screening plant. The size of the stone chosen shall be as large as is practicable to use in the thickness of pavement desired, about ½-in. or ¾-in. being suitable to use in a pavement 2 ins. thick, and a smaller size for pavements of less thickness.

GRAVEL.—Gravel may be used in place of the stone, or it may be mixed with the latter. It should conform in general to the specifications for stone.

SAND.—The sand shall be clean and hard, the finer particles sharp and angular. The grading of the sand obtained by screening shall be similar to the grading of sheet asphalt mixtures; that is, from 1/10-in. down to 200-mesh material. The latter, which may be classed as dust, should be not over 5% of the whole mineral aggregate.

ASPHALTIC CEMENT.—The mineral-rubber asphaltic cement shall be "Sarco" road compound manufactured by the Standard Asphalt & Rubber Co. (Chicago), or material equal thereto. Samples shall be furnished to the engineer and be shown by analysis to comply with the following requirements, such analysis to be made by a chemist experienced in the analysis of hydro-carbons.

The asphaltic cement shall be 99.5% pure bitumen soluble in carbon bisulphide. Such bitumen shall contain from 73% to 76% petrolene, soluble in petrolic ether of 86° Baume; and from 24% to 26% asphaltene, soluble in chloroform and not soluble in petrolic ether. The melting point shall be not less than 180° nor more than 190° F.

Using the Dow penetration machine, the asphaltic cement shall not vary more than 5 millimeters in penetration from the following standards (with a No. 2 needle):

42 mm. at 32° F. with 200 grams weight for 1 min.
62 mm. at 77° F. with 100 grams weight for 5 secs.
114 mm. at 115° F. with 50 grams weight for 5 secs.

The asphaltic cement shall be of a specific gravity of 98.5 at 77° F., and weigh 8.2 lbs. per U. S. gallon. When 20 grams of the asphaltic cement are heated in a dish 2¼ ins. diameter and 1 5/16 ins. deep, for 7 hours in an oven at a constant temperature of 325° F., it shall not lose in weight more than 0.5%.

METHOD OF MIXING.—The crushed stone (or gravel) and sand shall be thoroughly dried before mixing with the asphaltic cement. The driers shall be of the revolving type, thoroughly agitating and turning the material during the process of drying. When the stone (or gravel) and sand are thoroughly dried and heated to a temperature of from 250° to 300° F., they shall be immediately mixed with the asphaltic cement.

The asphaltic cement shall be melted in a tank arranged so that the heat can be controlled and regulated. When melted and raised to a temperature of from 300° to 325° F. it shall be combined in the proper proportions with the hot sand and stone (or gravel) and immediately mixed in a mixer with revolving blades until a thorough and intimate mixture of the ingredients has been accomplished, and the mineral particles evenly and thoroughly coated with the asphaltic cement. The mixer shall be arranged so as to retain the heat during the process of mixing, but shall not be exposed directly to the action of the fire.

METHOD OF LAYING.—While still hot from the mixer, the paving mixture shall be spread evenly on the base with hot iron rakes so that when compressed with a roller it shall have the thickness desired, with a surface even and true to grade. Along the curb and around manholes and other obstructions in the street, where the roller cannot reach, the compression shall be got by the use of hot iron tampers. The tamping shall be done as quickly as possible after the material is spread, while it is still hot and pliable. As soon as the temperature will admit, the paving mixture shall be rolled with a steam roller weighing at least 5 tons, and the rolling continued, working both across and lengthwise of the street until no more compression of the material can be effected.

The paving shall be done as nearly continuously as possible so that the joints between the hot and cold material shall be as few as possible. When a joint is unavoidable, the section of cold material shall be roughly brought down to a feathered thin edge, the surface where the joint is to be made painted over with pure asphaltic cement, the hot material raked over the feathered edge and thoroughly rolled.

The faces of the curb, iron frames of manholes, etc., shall be painted with asphaltic cement before the paving mixture is laid against them.

TOP DRESSING.—Before the rolling is finished, a top dressing of coarse torpedo sand, or stone chips, shall be spread over the surface while it is still fresh and plastic. The rolling shall then be completed, forcing a layer of the sand or stone chips into the surface.

An Infiltration Well at Coshocton, Ohio.*

By A. M. FISHER.†

The present water-supply of Coshocton is obtained solely from one cylindrical infiltration well having an inside diameter of 30 ft. at the bottom and a diameter of 32 ft. at the springing line of the spherical arch brick covering. This springing line is located 24 ft. above the bottom of the well and the arch has a radius of 20 ft. and an internal rise of 8 ft., making the total inside depth of the well 32 ft. It was constructed in 1900 at a cost of $4,500. This well has a manhole at the top even with the general surface of the level field surrounding the same, and the manhole is fitted with a water-tight rubber gasket and metal cover securely bolted down and locked.

The well is located in the glacial drift between the Walhonding and Tuscarawas rivers at a point 90 ft. east of the former and 240 ft. west of the latter.

Both of these rivers and the space between them are underlaid with gravel and sand. At a recent examination of the interior of this well when both rivers were at zero height, city datum, or 8.55 ft. below the top of the well, and when the pumps were running and exhausting from the well at the rate of 1,503,360 gals. per day, the surface of the water within the well was observed to be at the level of 17.55 ft. below the top of the well; that is, the pumps held the surface of the water within the well 9 ft. below the surface of the rivers. The pumps were then stopped for 15 minutes and during this interval of time the surface of the water within the well ascended 27 ins.

The infiltration or bottom area of this well is 706.86 sq. ft. and all the water that enters it must pass up-

*From a paper presented at the Convention of the Central States Water Works Association, Columbus, Ohio, Sept. 28.

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ward through the interstitial spaces of the gravel and sand composing this area. This shows that the infiltration capacity for each square foot of bottom area of well, under the conditions stated, is 2,126 gals. per 24 hrs. This seems to be an extraordinary rate of infiltration when compared with the following rates, the data of which were obtained from the excellent treatise on hydraulics by Mr. J. T. Fanning, of Minneapolis:

	Gals. per 24 hrs. per sq. ft. of area.
Lowell, Mass.	150
Brookline, Mass.	490
Toronto, Can.	52
Perth, Scotland.	182
Angers, France.	300
Genoa, Italy.	1,282

This rate of infiltration within our well indicates an average upward vertical velocity therein of 0.038 in. per sec., but this velocity is not sufficient to carry up sand whose particles are as large as 0.01 in. in diameter.

Five or more years ago the water in this well rose nearly as rapidly as it does now, but with much less head of water then. This would seem to indicate that the capacity of the well is slowly decreasing and that the pores of the gravel surrounding the well and beneath its bottom are gradually silting up with finer material thereby choking and retarding the entrance of the water. This condition is also the experience of probably a large majority of such infiltration wells and galleries constructed throughout our country.

The Determination of Power Station Load Factors.

The "Question Box" bulletin prepared for the annual meeting of the American Street and Interurban Railway Engineering Association, presented an enquiry as to the exact definition and basis on which power-station load factors are worked out, especially in combined railway and lighting stations. The replies printed in the bulletin were as follows:

United Rys. & Electric Co. (Baltimore).—We supply railway current only and base our station load factor on the formula:

$$\text{Load Factor} = \frac{\text{Total daily output}}{\text{Rated capacity of station} \times 24}$$

Washington Ry. & Electric Co. (Washington, D. C.).—We figure our power-station load factor as follows: We take the maximum ampere or kilowatt demand for any time during the 24 hours, multiply by 24, and divide this into the daily output for the day. This gives us our load factor for the day.

Public Service Ry. Co. (Newark, N. J.).—Load factor means the ratio between maximum load and output, and is obtained by dividing output by maximum load, multiplied by time. Thus:

$$\frac{\text{Total output for given time (in KW.-hrs.)}}{\text{Maximum load (in KW.)} \times \text{time (in hours)}}$$

For instance, if the maximum load in a station is 1,000 KW. and the output for 24 hours is 12,000 KW.-hours, the load factor is 50%:

$$\frac{12{,}000}{1{,}000 \times 24} = 0.50.$$

This applies equally to any station, whether lighting or railway. In many cases superintendents use the station capacity, or machine rating, instead of actual maximum load, but this method is very misleading and not correct.

Prof. Geo. C. Shaad (University of Kansas).—The true definition of load factor is the ratio of the average demand made on the station to the maximum normal capacity of the station. A station would have a load factor of unity if it were loaded to its maximum continuous capacity 24 hours each day.

On account of the fact that the ratio between the maximum capacity and the maximum load on any station is a changing quantity, it is customary to calculate the load factor on the basis of maximum demand and not on the basis of maximum capacity. The definition then becomes: the load factor of a station is the ratio of the average load to the maximum demand on the station. This is the definition commonly used in practice.

The load factor may be calculated for any period of time; a day, a month, or a year. In any case it is the average load for the period, divided by the maximum load occurring during that interval of time. In central station practice the load factor for periods of less than one year has little significance.

One company, which has the management of several stations that supply a combined load of lighting and railway power, records the load factor for each station at the beginning of every month as calculated for the year just ended. The load factor in this case becomes:

$$\text{Load Factor} = \frac{\text{Output for year just ended, in KW.-hrs.}}{\text{Maximum load in KW. occurring during the year} \times 8760.}$$

Steam Rollers Used in the Construction of the Earth Dams for the Ashokan Reservoir.

In building the dam and dikes which are to confine the waters of the new Catskill reservoir for the water-supply of New York City, special steam rollers are being used to compact the material placed in the earth dams. Besides the main dam across the valley of the stream whose waters are being impounded, a number of dams of smaller height are required to close low places around the borders of the reservoir. The total length of the dams and dikes to be built amounts to several miles.

Except for the main dam, which is of masonry construction, the structures are earth embankments with a core wall at the heart. The specifications require these earth fills to be made from earth containing no vegetable matter, and no stones of a diameter larger than 6 ins. The clause covering the compacting of the material as placed is as follows:

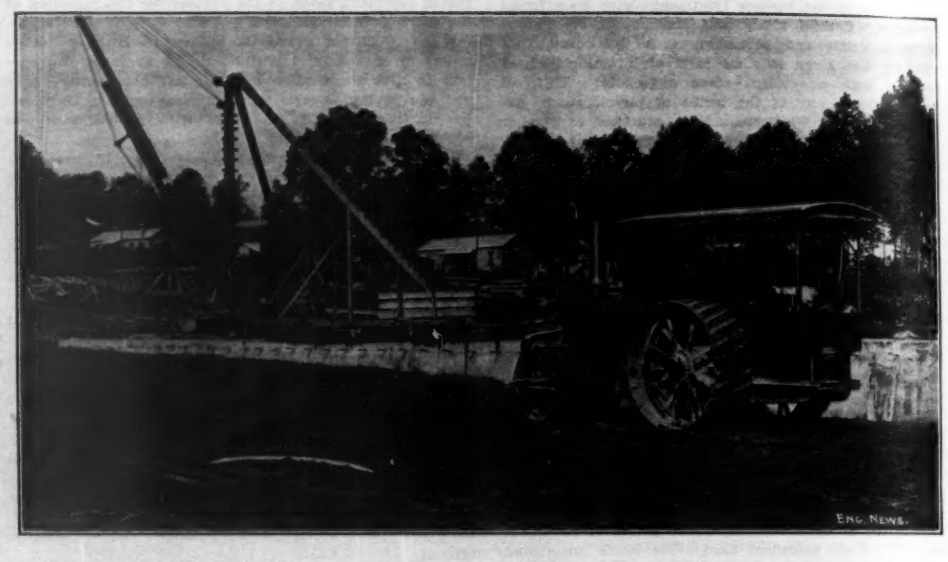
Compacting of loose earth shall be accomplished by approved steam rollers with grooved or banded rolls. The rear wheel or wheels of the rollers shall be of such width and diameter, and shall bear such a proportion of the total weight of the roller, that with a penetration of 1 in. it shall cause a calculated average pressure on the bank of at least 30 lbs. to the square inch on its entire bearing surface. The bearing surface considered will be the width of the roll multiplied by half the arc bounding a segment of the roll, at the bottoms of the grooves, having a middle ordinate of 1 in.

To comply with these specifications, it was necessary to have engines with two rear wheels, similar, in fact, in general design to the traction engine for use on highways, as a broad roller at the rear would not have given sufficient weight to meet the specification requirements. The front wheel of the roller, which also acts as the steering wheel, is grooved, as may be seen by reference to the accompanying cuts.

Ten steam rollers of this type, built by the Monarch Road Roller Co., of Groton, N. Y., are in use by the contracting firms which are building the dams, MacArthur Bros. Co. and Winston & Co. In the design of these engines, special pains have been taken to secure durability and freedom from breakdowns, in order that the work may not be interrupted. With the short working season—it being necessary to suspend all work during the months of freezing weather, and also during heavy rainstorms—delays on account of breakdowns in machinery must be avoided as far as possible.

The work thrown upon the driving engines of these rollers is very heavy, since they are continually traveling in soft, wet earth, in which the resistance to motion is great. To meet these requirements, the boiler of the machine has an unusually large heating surface and extra large driving gears are used, while steel has been substituted for cast iron in a large part of the construction.

The accompanying views show also the construction of the concrete core walls against which the embankments are built up.



STEAM ROLLERS USED IN BUILDING EARTH DAMS FOR THE CATSKILL WATER SUPPLY.

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More than two-score years ago the New York legislature granted to Alfred E. Beach and others the right to lay pneumatic tubes beneath the streets of New York and Brooklyn for the conveyance of parcels, mails and merchandise. Beach was an inventor and one of the editors of the "Scientific American." A short tunnel, 294 ft. long, in which a car was moved by pneumatic power, was actually built at Warren St. and Broadway to demonstrate the possibilities of his scheme. This old Beach tunnel has been chiefly useful as evidence that the possibilities of subsurface circular tunneling beneath city streets were appreciated on this side of the Atlantic nearly 20 years before English engineers developed the shield-driven tube tunnel system beneath London's streets and the waters of the Thames.

Nothing practical was ever done with Beach's invention, and Beach himself died many years ago. But the grant to him and his associates did not die. Franchise rights, even though given thoughtlessly or corruptly do not die in consequence. Like the brook, they go on forever. The Beach franchise, originally owned by the Beach Pneumatic Transit Co., was transferred in 1874 to the Broadway Underground Ry. Co., and in 1885 to the New York Arcade Ry. Co. This company sought added powers for the carriage of passengers and a generous legislature granted them; but the courts declared the grant unconstitutional. A serious obstacle to the construction by the city of its own Rapid Transit tunnel system was thereby eliminated.

The old franchise of 1868 did not die, however, and in 1897 the company holding it became the New York Parcel Dispatch Co., and secured an amendment to its charter authorizing it to use electric as well as pneumatic power. In the dozen years since then, it has done nothing toward the utilization of its franchise. The fact that such a franchise still exists was only brought to public attention on Oct. 15 by an application to the Public Service Commission for approval of the company's plans. It is said that this long dormant franchise is at last to be put to use and that engineering work upon the enterprise has been done by Mr. L. B. Stillwell.

We have briefly rehearsed this history of a sleeping franchise because it is an illuminating example of the way franchises ought not to be granted. What did the legislature of 1868 know about the needs of the New York City of 1909? Would that legislature have granted the franchise they did, had they known it was to lie dormant for over 40 years? We are aware that the common argument for the liberal granting of franchises is that they stimulate development. But franchises handled on the dog-in-the-manger plan are more often used to hinder bona-fide development and to levy blackmail on honest and genuine enterprises than as a basis for actual business.

Sooner or later, it seems to us, the issue must be settled whether these holders of ancient franchises shall be permitted to retain them in perpetuity. It is unthinkable that the grant of a piece of public property away back in the 19th century shall be made a basis for laying burdens upon those who live in the 20th century and the 21st century and all succeeding eras to the end of time.

The Pennsylvania Railroad is making a commendable effort to reduce the loss of life among those who follow the dangerous practice of walking on the track. Few people realize that the number of persons killed annually while walking on railway tracks is far greater than the number killed in all the train collisions and derailments.

Notwithstanding all that is being done by American railways to rid their lines of trespassers, the deaths among those walking on the track steadily increase. In 1898 the number of trespassers killed on American railways was 4,063; in 1907 the number was 5,612—more than 15 persons killed for every day in the year. On the Pennsylvania R. R. lines alone, 915 trespassers were killed in 1907. In the ten years prior to Jan. 1, 1909, no less than 7,240 people were killed by trains while walking on railroad tracks of the Pennsylvania system.

Practically all of this enormous death roll is traceable directly to the American habit of using railway tracks as a thoroughfare. The railways endeavor to combat this habit by arresting persons for walking on the railroad track, but it is very difficult to secure punishment of the trespassers in the petty courts where such cases are tried. If it were possible to punish trespassing as severely as it is punished in England, it would be easy to put an end to the present terrific loss of life among those who use railway tracks as a thoroughfare.

Newark, N. J., is considering a proposition that the city shall acquire some 4,000 acres of unimproved land on its outskirts in order to benefit by the rise in value anticipated from extensive dock improvements which the city proposes to undertake upon the tract. The plan originated with the Mayor and has been approved by the Board of Public Works.

There is no precedent for this, so far as we recall, in this country. American cities have purchased lands for parks, schools, docks, markets and similar public purposes, and such lands have at times been leased to private parties in the interim before conversion to public use; but for the city itself to reap the benefit from "the unearned increment" or the rise in value of real estate due to its growth, is a new proposition in democratic America. There is precedent for it, however, on the other side of the water. In monarchical Germany, cities do things that would be thought revolutionary here. A story has recently been published concerning one German city which has purchased and retained the fee of lands in its suburbs which have rapidly increased in rental value. The income derived from this property of the city is now sufficient to meet all demands on the city treasury for carrying on the public business, and yields in addition an annual dividend which is paid over to each taxpayer.

We cannot now vouch for the truth of this story, and if true it represents of course an extreme case; but it is certainly a fact that in many instances cities in England and Germany have engaged in large enterprises in the improvement of lands and have handled the work in such a way that the rise in land values has benefited the city treasury, or in other words the taxpayers as a whole. If the same work had been done in an American city the chances are that the rise in values would have been divided between a few shrewd real estate speculators and a few equally shrewd city officials who had knowledge in advance as to the prospective work and consequent advance in land values and who used this knowledge for their personal benefit.

We pass no opinion on the merit of the particular scheme which Newark is considering for development of docks and water terminals. But if it is worth while for the city to undertake it, then it ought to be worth while for the city to reap the benefit in the resulting advance in real estate values.

Newark's proposed municipal docks are a reminder of the extent to which municipal dock construction is being established as a policy in every large commercial city located on tidewater. It is becoming generally understood that it as absurd for a city to permit some outside interest to control its facilities for the entrance of water traffic as it would have been for any ancient walled stronghold to have permitted some alien to control the gates through which alone access to the city was obtained. Of course municipal docks are nothing new abroad. The docks of Liverpool, of London and of Manchester are world famous; but we have been slow to learn in this country the lessons of foreign experience. Now, however, New York owns a large proportion of the water front of Manhattan Island, and the latest piers built on the North River are unequaled in the United States. Commercial interests of the port continue to clamor for further extensions.

Boston plans the complete reconstruction of its water terminals on an enormous scale, and has a commission engaged on studies for the work, as described in our issue of April 1, last. Baltimore voted $6,000,000 to rebuild its burned piers after the great fire, and the voters are to ratify $1,000,000 additional at the fall election. This, however, is only the beginning. Mr. Lackey, the Harbor Engineer of Baltimore, intends to ask the legislature to permit Baltimore to borrow $50,000,000 for improving its waterway terminals, the work to extend over a long period of years, perhaps at the rate of a million dollars a year. On the Pacific Coast Los Angeles will endeavor to control the water front in its newly acquired port of San Pedro; and Oakland has just arranged for a bond issue of over two million dollars to construct docks. Even Philadelphia has awakened to the fact that the sea trade for which she has long been seeking needs proper harbor facilities even more than a deeper channel to the sea if it is to be attracted away from rival ports to the head of Delaware Bay.

The following statement serves well to illustrate the obstacles which some physicians place in the way of effective health-protective work. The statement is taken from the minutes of the quarterly meeting of the Michigan State Board of Health held at Lansing in October, 1909, and is as follows:

> Owing to the opposition of some members of the medical profession to making reports on contagious diseases to the health officer, a law was enacted at the last session of the Legislature authorizing the State Board of Health to designate those diseases which are communicable and dangerous to the public health and which must be reported by the physician to the local health officer and by the local health officer to the State Board of Health; and in compliance with this law, the Board has declared the following diseases to be dangerous communicable diseases which must be reported by physicians to the local health officer, and by the local health officer to the State Board of Health: Pneumonia, Tuberculosis, Typhoid Fever, Meningitis, Diphtheria, Whooping-cough, Scarlet Fever, Measles and Smallpox.

One would suppose that physicians would be the first to recognize the advantages of making prompt reports of every case of communicable disease. Perhaps as a class they do, but, as every local and state board of health and registrar of vital statistics knows, there are still

many exceptions. In addition, through carelessness or exacting demands upon their time, many physicians who appreciate the importance of reporting cases of communicable diseases fail to do so, and thus greatly impede health-protective work. All intelligent citizens should bring such pressure as they can to bear upon physicians, as a class and as individuals, to lessen this remissness in a most important public duty. Sanitary engineers and municipal authorities generally are, or should be, particularly interested in bringing about much-needed reforms in this particular.

In commenting in our issue of Oct. 7 on the recent calibration of the Phoenix hydraulic testing machine, we referred to the comparative tests made on the same machine and the Watertown machine in 1896-'97 as an "alleged" calibration. We did not intend by the term to reflect in any way upon the engineers who carried on the tests at that time. In fact Mr. Jas. E. Howard, who conducted the recent tests, cooperated in the tests made a dozen years ago. Without doubt the engineers who made the tests at that time thought they had used every necessary refinement to ensure accuracy. To illustrate this, it is on record that the proposition was even discussed of correcting the results for the change in modulus of elasticity of steel at different temperatures, in view of the fact that the testing room at Phoenix was several degrees colder than the one at Watertown.

Notwithstanding all the pains taken, it now appears that that calibration was so wide of the truth that it misled the engineering profession instead of aided it to greater accuracy. As to how the large error arose, there appears to be even now no certain knowledge. Mr. Howard, from his report in our issue of Oct. 7, apparently thinks the results of 1896 were vitiated because the compression measurements were taken on a single segment only of the 8-segment Phoenix column used. It is possible, also, that there may have been an error in the pressure gage used at the time.

Few engineers deny the labor-saving convenience of a standard system of nomenclature. Why is it, then, when such a system is easily available that the average technical writer deliberately avoids it?

During the years while the design of reinforced-concrete work was comparatively new, every writer used algebraic notation to suit himself in the theoretical analysis of beam and column. Gradually, however, there grew up a semblance of a standard system of naming for the various forces and dimensions used, and these standards were finally crystallized into the system given in the recent report of the Joint Committee on Concrete and Reinforced Concrete. That system is plain and clear and has the distinguishing merit of being, for the most part, already well known to those interested in the subject. Its use by writers on the theory of concrete would do away with much of the initial difficulty in understanding the discussion.

It seems rather strange, therefore, to note in the last number of the "Journal of the American Society of Mechanical Engineers," an article on "Stresses in Reinforced-Concrete Beams" in which an entirely new system of notation is employed. Of the thirty or so terms used only three are the same as those of the Joint Committee, although the same letters are used in each to express different dimensions or forces. Examination of the notation in this paper shows that it bears a sort of family resemblance to that recently proposed by a committee of the International Society for Testing Materials, a committee composed almost entirely of continental European experts. Possibly the American committee ought to have considered the work of its European contemporary in making the new standards; but as long as it did not, it certainly will be much more convenient for all concerned if the American standards be followed. This matter of simple notation may seem only incidental to the author who is absorbed in his studies, but he will find that often it will make the difference between having his work read and having it overlooked.

Temperature Stresses in the Members of Steel Structures.

If one lays his hand on an iron railing or the edge of a tin roof upon which a hot summer sun has been shining, he will realize very quickly the heating power of the sun's rays and the surprising intensity of local heating which it may produce. The metal is often hot enough to burn the hand, even in northern latitudes. In southern regions metal tools left in the sun cannot be used with bare hands.

In the case of a thin plate of metal such as a tin roof, the amount of material to be heated is small, its heat absorbing surface large and the backing is a good non-conductor. But when the cap rail of an iron balustrade feels hot to the touch the state of affairs is different, for the thickness of metal behind the absorbing surface is very considerable, and there are many paths by which the heat can be conducted down out of the cap rail to other parts having lower temperature. As a matter of fact, the rail as a whole is not heated up very much. Upon touching the bottom face of the rail we find it almost as cool as a piece of metal lying completely in the shade. But we can have no doubt that the upper surface on which the sun shines directly is very perceptibly hot.

All steel structures exposed to the sun are affected in just the same way. Where the sun shines upon the surface of the metal there is a marked local heating as compared with the temperature of the mass of the metal or those surfaces which are in the shade. As we know that heat causes expansion of metal, or tends to cause it, we know that these hot surfaces must have a tendency to expand in relation to the cooler metal beneath and, the expansion being restrained by the resistance of the cool metal, a compressive stress must be set up in the warm surface layer.

What bearing has this phenomenon on the strength of steelwork? We know practically nothing in the way of facts beyond the very general observations just stated. We are able to say with certainty that the effect of direct sunshine, in producing a local heating which we can readily feel, must produce various local stresses in the metal, additional to the stresses imposed upon the metal by its service in carrying loads. But whether these heating stresses have any practical importance; whether they amount to ten or a hundred or a thousand or even ten thousand pounds per square inch, we do not know. The subject has not been investigated, and our treatises and books of instruction are uniformly silent concerning it.

The fact that all existing steel structures show no injury or no evidence of effects of these heating stresses furnishes good reason for believing that they are not so severe as to be dangerous or injurious in a structure designed for moderate working stresses. Should we, however, permit our working stresses to increase and approach more closely the physical limits of the metal, we may be compelled to deal with the secondary stress arising from local heating, and study its amount and distribution.

Moreover, in large or special structures the disposition of the metal, etc., may be such as to bring the question into prominence. For example, in the latest of the large East River bridges, a suspension bridge having steel towers, now being built in New York City, the towers are cellular shafts of steel plate-and-angle construction, completely closed, and having most of their vertical bearing power concentrated in the plates which form the outer surface of the shaft. In cross-section these towers are very far beyond the dimensions of any similar supporting structure of steel built previously. If we consider the side face of such a tower—a steel-plate wall 20 ft. wide and several hundred feet high—we may easily imagine that the sun shining on this face continuously for several hours will heat the entire thickness of plating on the exposed side to a temperature quite considerably above that on the shaded side. In a free-standing single tower or pillar this action would produce a bending away from the sun. In a pillar which is rigidly braced to another to form a pair or bent, the deflection is likely to be restrained more or less completely, so that the effect of temperature is to develop certain stresses in the structure.

In the towers referred to, working stresses exceeding 20,000 lbs. per sq. in. are employed. Where the regular stresses are so high, secondary stresses of all kinds naturally become important. It would seem proper under the circumstances that we should take steps to assure ourselves as to the possible amount of the local heating effects, or at least to prove that they cannot be more than of negligible amount. A secondary stress which should run up to several thousand lbs. per sq. in. would cut into the margin of safety quite seriously; and in the case of a structural part which, like these towers, is fundamental to the integrity of an important bridge with a half-mile of heavily traveled roadway, such reductions of safety are of primary moment.

Another pertinent illustration is the unfortunate lower chord of the Quebec Bridge. Among the possible causes of failure suggested to us by correspondents at the time was the heating of one of the four heavy slabs of which the member was built up by exposure to the sun on that side. Even a few degrees higher temperature in this slab would cause perceptible elongation in a member of such great length and there would be a consequent tendency to bow the chord out of line, and if this were prevented then this slab would carry more than its proportionate share of the load.

Under the circumstances at Quebec, it did not appear to us likely that this local heating had anything to do with the final failure; but we can conceive of circumstances—exposure to a tropical sun, for example, where temperature stresses in a steel member might become very serious; and the subject seems to be one deserving the careful thought of structural designers.

The general attitude hitherto in regard to the possible local effects due to the sun's heat has been that they are positively negligible; that the marked rise in temperature which we feel on the surfaces exposed to the sun is purely superficial, without any relation to the temperature or behavior of the general mass of metal concerned; in short, that the subject was not even worth investigation. We are not aware of any basis of observed fact for this view. On the contrary, there is occasional evidence pointing to the probable importance of temperature effects and suggesting that they may need a careful and serious study.

If for the moment we make an extreme assumption, we may suppose that a steel member has an average temperature of 80° F., but on the surface exposed to the sun is heated to 130°. If the heated layer is very thin in comparison with the body of the member, it will be restrained from expanding and its rise of temperature will produce compression in it. The expansion coefficient of steel being about seven parts per million, 50° will produce a free expansion of 350 parts per million. To prevent or restrain this expansion in a material whose coefficient of elasticity is 30,000,000 requires a compressive stress of

$$30{,}000{,}000 \times \frac{350}{1{,}000{,}000} = 10{,}500 \text{ lbs. per sq. in.}$$

The possibility of local secondary stresses anywhere approaching such amounts is disquieting.

A rough measure of heating effects on a bridge is given by an instance reported recently from England. A simple span of 350 ft. was being erected in cantilever fashion. When the parts projecting from either abutment were near closure, it was noticed that temperature effects caused marked lateral deflections of the projecting mass of steelwork. It is recorded that during a spell of warm September weather the outer end of the cantilever portion moved laterally 1⅝ in.

The overhang was about 175 ft. long; the width of bridge between trusses was 32 ft. Assuming that the lateral deflection was due to the excess expansion of one truss compared

with the other, we can compute that the truss on the sunny side was about 34° warmer than the other truss, on the average. The face directly exposed to the sun must have been very much warmer than the average of the whole truss, and to estimate the maximum heating produced in this case we must doubtless set the figure very much higher than 34°. But a heating of only 34° would, if fully restrained, cause a compression exceeding 7,000 lbs. per sq. in.

Without attributing much importance to the specific figures of the preceding calculation, we yet are compelled to conclude from the facts cited that the heating effect of the sun's rays shining upon a large steel bridge may be great enough to form an appreciable addition to the load stresses, and that the action merits serious investigation and study.

Temperature effects revealed themselves in a somewhat different way recently in connection with another important steel bridge. Some time ago Mr. J. E. Howard, Testing Engineer at the Watertown Arsenal, worked out a method for measuring bridge stresses—not merely the live load effects, as investigated by other experimenters previously, but the dead load stresses, which had never been measured. He constructed the necessary apparatus, and during the past summer undertook to apply the method to the large cantilever bridge which the Pittsburg & Lake Erie Ry. is erecting at Beaver, Pa. His method depends upon how reliably the distance between two fixed gage-points on the face of a steel member can be measured. The form of the gage-points and the nature of the measuring apparatus permits of high accuracy. A primary requisite, however, is that the standard-length comparison bar be at the same temperature as the bridge member which is being measured; for a difference of 1° F. will make a difference of length equal to the minimum reading of the apparatus. Incidentally, the member itself should be uniform in temperature, so as to be free from momentary local stresses and indicate truly what total stress the member is carrying.

It soon developed that even with a member not yet erected it was almost impossible to get the same reading twice. The temperature seemed to be varying and shifting constantly. The member was never in thermal equilibrium, but was moving and changing shape continually. The differences between successive readings were far above the possible accuracy of the instruments.

This affords a clear demonstration that local temperature effects do exist in the members of steel structures. It indicates that they are important enough to be worth study, if not so important as to compel study.

At the same time it suggests one means by which these effects may be studied. A detail knowledge of the changes of length at different points of a member is the first step to a knowledge of the stresses involved in those movements. But this alone will not show what surface stress is produced by local heating, and generally speaking will not give the temperature stresses. Accurate observations of temperature must be combined therewith. The two sets of data together will supply a complete basis for the remaining computations.

We trust that investigations of this kind may be undertaken soon. There is need for them, if our knowledge of structures is to continue progressing toward higher precision. The stress measurements of Mr. Howard may give some of the needed data as a by-product.

LETTERS TO THE EDITOR.

Part of a Beam Stronger Than the Whole.

Sir: One of the most interesting paradoxes of the theory of beams is that part of a beam may be stronger than the whole, so that a beam can sometimes be made stronger by cutting away part of its cross-section. A practical example of this may bring to mind facts which will further the avoidance of poor shapes in special types of beam better than mere perusal of moment-of-inertia tables would.

Considering the general case of a beam of section symmetrical with respect to its vertical and horizontal axes, the moment of resistance to bending is $\frac{p\,I}{y}$, where p is the limiting fiber stress, I the moment of inertia of the section around its horizontal axis, and y the height of the section above and below this axis. Now if the section is of pointed shape, so that decrease of y will be greater than corresponding decrease of I, the beam will be strengthened by the removal of part of itself.

To show what is meant, draw for the beam section, Fig. 1, the curve $O\ X$, which, for values of y equal to its ordinates, shows by its abscissas the corresponding values of the moment of resistance to bending. The typical form of the curve is as given, and in general it

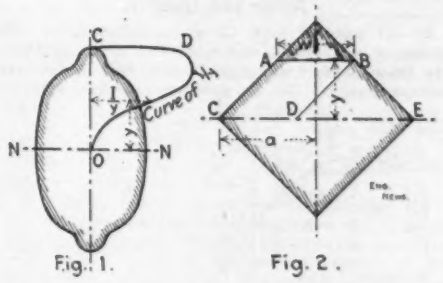


Fig. 1.

Fig. 2.

may be said that the maximum abscissa is farther from the top the more pointed the section is at top and bottom, though of course for some sections, as for instance rectangular wooden floor beams, as usually laid, there is a steady increase in the strength with increase of y, instead of an increase up to a maximum and then a decrease again.

Take the case of a beam of square section, with neutral surface through two diagonally opposite edges, Fig. 2. Let a be the semi-diagonal, and w the width of section at distance y from the neutral surface. Then $w = 2\,(a-y)$, and summing the moments of inertia of the areas $A\ B\ D\ C$ and $B\ D\ E$, multiplying by p and dividing by y, we get the moment of resistance to bending:

$$R = \frac{p\,I}{y} = \frac{2\,p}{y}\left[\frac{2\,(a-y)\,y^3}{3} + \frac{y^4}{6}\right]$$

$$= \tfrac{1}{3}\,py^2\,[4\,a - 3\,y]$$

and equating the derivative to zero gives a maximum strength when $y = \frac{8}{9}\,a$.

For a beam of circular section y is approximately $0.96\,a$, by the same method, though that case is very much more difficult.

This amounts to proving *part* of a beam sometimes stronger than the *whole* of it; at least the whole beam will crack when part of it would not have cracked. However, the crack ought really not extend down into the part that would stand the stress alone, though in practice, if a crack ever started, the chances are that it would continue past the critical point and sever the beam.

Garret L. Schuyler,
Midshipman, U. S. N.

Washington, D. C., Aug. 29, 1909.

Still More About the Petrolithic System of Road Construction and Results Under Service.

Sir: In your issue of Sept. 23 you publish at considerable length reports on petrolithic pavement. We will not ask to take up much space in your paper with our statement of the facts of this question as we know them, but we do ask that in justice to the Petrolithic Pavement Co., of Los Angeles, Cal., and numerous other companies doing this class of work throughout the United States, you publish in as conspicuous a manner as the article above referred to, at least some of the several letters enclosed herewith. If you do so we will be satisfied to abide by the judgment of the engineering world as to the statements made by these several gentlemen.

In this connection it might be stated that all the petrolithic streets thus far constructed in the city of Los Angeles have been built under specifications which called for either no road metal or at most 2 ins. of gravel. The work being done in El Paso and most places where the process has been taken up during the last two years is done under specifications calling for at least 3 ins. of crushed rock. This gives a much better street, and it is hardly fair to utterly condemn all tamped or petrolithic streets because of the failure of some of the cheaper class of construction.

Yours very truly,
Petrolithic Pavement Co.,
Holmes Ellis, Treasurer.

Los Angeles, Cal., Oct. 4, 1909.

[From the eleven testimonials sent by the Petrolithic Pavement Co. we have selected and here reprint extracts or entire letters giving information of probable interest to our readers, as follows:

Monrovia, Cal., Jan. 14, 1909.

The Petrolithic & Construction Co.,
9 and 10 Masonic Bldg., El Paso.

Gentlemen: . . . after many experiments in our city with this pavement, we have finally adopted petrolithic pavement for the improvement of all our streets and find it very satisfactory. Many of our streets were improved about four years ago and have not as yet needed any repairing, though subjected to considerable traffic. . . . We have built over twenty miles of this pavement and have several miles under way. We have found it satisfactory in all kinds of soil, the heavier soils requiring a mixture of two or more inches of crushed stone or gravel.

Yours respectfully,
F. M. Monroe, Street Superintendent.
H. S. Gierlich, City Engineer.

Ventura, Cal., July 3, 1909.

Mr. F. H. Todd,
City Engineer, El Paso, Tex.

Dear Sir: . . . Our soil here has no grit in it and my first idea was to use 2 ins. of gravel in the surface to supply the deficiency, but the supply of gravel was limited, so we bought a crusher and substituted crushed rock. The rolling tamper is also a fine mixer and by no other method can such a firm, homogeneous foundation and dense combination of soil, rock and oil be secured as with the use of these rollers.

There have been various specifications gotten out for oiled macadam roads. They all roll a sub-grade with a steam roller, then a layer of crushed rock, followed by a layer of smaller sized rock, or perhaps several sizes. Each layer is rolled and sprinkled and rolled, all with a steam roller. Then hot oil is put on and it is covered with finer gravel or screenings. There is bound to be, and it is unavoidable in this method of construction, interstices of more or less magnitude in these rock courses. It seems to me that hot oil put on in this manner results in a large percentage of waste, oil filtering through into voids where for all purposes of road building it is lost. We aim in the petrolithic pavement to secure a thorough mixture of the oil and soil on a homogeneous foundation and in the upper portion place 2 to 4 ins. of crushed rock according to judgment as to travel. This rock is thoroughly mixed with the oiled soil and pounded into a very dense mass by the feet of the rolling tampers. There is no possibility of any voids in our work and we secure results from every drop of oil used.

In some cases the so-called petrolithic process has not been a success, but if these are investigated, in every case it will be found not the fault of the method, but the result of using an oil unsuited to road building or to workmen who do not care and take no pains and interest in doing good work. Poor workmanship will spoil good material and the best workmen cannot do good work without the material to work with. This is the only cheap pavement that the automobile traffic cannot disintegrate.

Yours truly,
J. B. Waud, City Engineer.

Santa Monica, Cal., July 1, 1909.

Mayor J. U. Sweeney
and
City Engineer F. H. Todd,
El Paso, Tex.

Gentlemen: . . . When the work was first started we did not incorporate any crushed rock into the pavement, but used only the natural soil as it was found in the street. Our soil differs materially, ranging from fine sandy soil to heavy clay soil. The results secured in some of our oldest work in sandy soil, which has been down about five years, are decidedly satisfactory. During the development of this class of work we have found that we secured more satisfactory results where we incorporated at least 2 ins. of broken stone into the wearing surface of the roadway.

When properly constructed, these streets are not affected by automobile traffic, and they are practically free from dust or mud during the rainy season.

Thos. H. James, City Engineer.

South Pasadena, Cal., March 19, 1909.

Mr. W. A. Wilson, City Engineer,
Roswell, N. Mex.

Dear Sir: . . . Our experience is that for streets sustaining heavy traffic the petrolithic system with its various modifications offers the most satisfactory pavement within our reach. Our specifications are practically the same as the most recent ones adopted by the city of Los Angeles.

The character of our soil is mostly of a clay nature. Our oldest petrolithic pavement is about two years old and our newest one about one month old. Our petrolithic streets sustain what might be termed moderate traffic, some of which is heavily loaded wagons, such as gravel and oil wagons. All of our petrolithic streets are at present in excellent condition, and it is our opinion that they will last not less than five years without

any repairs. In appearance they are smooth, free from any depressions, and very much resemble sheet asphalt.

The pavement when properly laid with 2 ins. of rock will withstand all ordinary traffic. If you build a street having 4 ins. of rock upon its wearing surface, you have done nothing more than built a macadam street differing in two essentials from the old style, namely, it will have a better foundation under it, and the rock-wearking surface will be more thoroughly cemented together, more impervious, and will withstand traffic better than any old style macadam street could possibly do.

Very truly yours,
B. F. Dupuy, City Engineer.

Glendale, Cal., Jan. 14, 1909.

The Petrolithic & Construction Co.,
El Paso, Tex.

Gentlemen: . . . We do not use any crushed rock, but take the soil as we find it, and with the "tamping roller" and three gallons of heavy asphaltic oil (80%) to the square yard build our streets.

I would consider a quantity of crushed stone used to finish with advantage. I have desired to use it but the people are so well satisfied with the present results that they will not stand for any increase in cost.

Yours respectfully,
F. R. Sinclair, Street Superintendent.

We have omitted portions of the foregoing letters and the whole of a few letters which were chiefly of the familiar trade catalog type. On the whole, all the letters were unqualifiedly in favor of the petrolithic method of road construction, as would be expected of letters selected for publication by the promoters of the system.

The letters here given should be read in connection with those in defense of the petrolithic method published in our issue of Oct. 14. All the letters together indicate that in numerous localities petrolithic roads have given general satisfaction for the relatively brief periods that most of them have been down and for the relatively light traffic, as we understand it, to which most of them are subjected. It is plainly evident, both from the adverse statements of Messrs. Campbell, Hamlin and Humphreys in our issue of Sept. 23, and the favorable letters in our issue of Oct. 14 and our present issue, that for satisfactory results over considerable periods and under heavy traffic the petrolithic roads must approach in general character other roads with bituminous binders. That is, a solid foundation and a firm and durable wearing surface must be provided. Or in other words, neither tamping or oil, alone or in combination, will convert local dirt into a firm, durable road surface *and keep it such*.—Ed.]

Sir: Being vitally interested in all forms of road construction in general, but financially interested in no one in particular, I have read with considerable interest the controversy in your columns in regard to the merits of petrolithic roads. Though much truth has been written on both sides, it would seem that much of the discussion has been beside the point in that petrolithic roads have been condemned on the one hand and defended on the other largely upon the basis of the materials entering into their composition.

According to what seems to be the correct meaning of the term, petrolithic applies not so much to materials as to methods of construction. The originators of this form of road say, "The word 'Petrolithic' is used to designate a *process* (italics my own) of which the essential features are, some hydrocarbon (preferably a heavy petroleum oil with asphalt base), and a rolling tamper." From this it is evident that a petrolithic road must be one constructed by that process, and that the only restriction as to material is that the binder shall be a hydrocarbon. As all of the bituminous binders in present use are fundamentally hydrocarbons, it follows that a road containing any of them as the cementitious portion of the aggregate, and constructed by the use of the rolling tamper, would fall under the classification of petrolithic.

While it is doubtless true that many petrolithic roads have failed, it is probable that in many instances the failure was due, not to any fault of the petrolithic process, but to the use of improper materials or else to the injudicious selection of the process for the construction of a road demanding quite different treatment. Like every other form of road, the petrolithic is not the best for all places and under all conditions, and its failure in one place is not necessarily an index of its unfitness for another. Even its warmest friends would not advocate its use for city streets carrying heavy trucking, but that would not be equivalent to admitting its unsuitability for some country road bearing a comparatively light traffic.

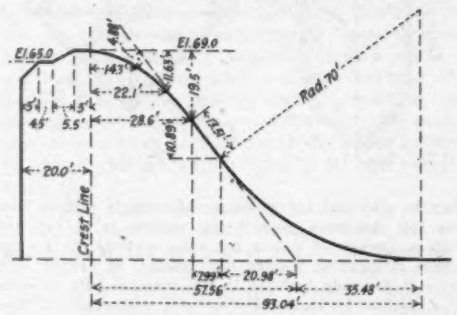
If the petrolithic road has failed in some places, it has succeeded in others, and under certain conditions it provides a satisfactory solution of the problem of securing a hard, dustless road at a reasonable cost. The use of bituminous binders is already recognized as good practice, and it is difficult to find flaws in the theory of the rolling tamper. Therefore, in the unqualified condemnation of the petrolithic road, it seems as if its enemies were either laboring under a misapprehension as to the meaning of petrolithic, or else were voluntarily arraying themselves against good practice and sound theory.

Yours very truly,
T. A. Hulbert.

1000 Simpson St., New York, N. Y., Oct. 15, 1909.

Notes and Queries.

In our issue of Sept. 23 we published on p. 336 a section of the concrete dam to be built at the spillway of the Gatun dam, drawing the section from a cut in the "Canal Record." We are now informed that the cut appearing in that journal contained a slight error in the dimensions given for total thickness of dam. We therefore reprint the section of the dam with the errors corrected.



Flue-Gas Analysis, Steam Meters and Low-Pressure Steam Turbine Plants.*

Flue Gas Analyzers.

Last year's work indicated that a great deal of uncertainty exists as to the real merits of the CO_2 flue-gas analyzer. The investigation showed at that time there were but few railway power-plant engineers who had attempted to make flue-gas analysis, particularly with the automatic recorder. Replies to inquiries sent to member companies this year recorded but 23 users of gas analyzers, an increase of only nine over last year.

The practice of analyzing flue gases as a part of the regular routine in conducting boiler tests has been the rule with engineers for some time, and is prescribed in the code of the American Society of Mechanical Engineers for conducting such tests. In this code the determination of CO_2, CO and O is provided for, and the benefit that comes from such determinations in all boiler tests is unquestioned, but the committee has endeavored to determine what value, for the purpose of developing and maintaining higher boiler efficiency, there may be in the practice of making either intermittent quantitative analyses of flue gases by the Orsat apparatus or continuous analyses with the CO_2 recorder.

Some of the ablest fuel engineers who have contributed articles on gas analysis and its relation to fuel economy have outlined in great detail the theory and results to be gained, developing the theory with pure carbon as a basis of fuel instead of coal with its various mineral and gaseous contents. Such articles have been, to a certain extent, misleading, because of the high percentage of combustible and non-combustible elements in coal in addition to the carbon. Since our coals are obtained from fields covering such a wide range of territory, and vary so in composition, it is essential that the power-plant engineer should know the composition of his coal, the better to enable him to determine in advance what percentage of CO_2 he should obtain in his flue gases for the best economy. Operating methods and design of grate and furnace are the important elements affecting the gas composition and making the problem very complex.

It is therefore very evident that there are many factors that enter into the problem of the proper utilization of fuel, and this subject is probably now receiving more attention from able engineers than ever before in the history of fuel consumption. The very thorough and valuable work which has been conducted for the past four years by the fuel-testing plant of the U. S. Geological Survey has had as one of its many subjects under investigation, "The condition under which different coals may be most economically burned," and its work has stimulated great interest in the subject.

For this reason any auxiliary device for aiding the proper handling of the furnace has been received with considerable enthusiasm by most engineers. Unfortunately, however, the advantages in economy to be realized by analysis of flue gases in the average plant have been largely overestimated, as replies received from engineers to inquiries sent out will verify.

Flue-gas analyzers and CO_2 recording instruments and their value in the boiler room have, to a very great extent, been overdrawn by their agents. A lack of progress and a great deal of discouragement has resulted on account of the average power-plant engineer expecting too much with too little effort in the use of such devices.

It is conclusively shown from the many replies received that the efforts of engineers to make flue-gas analyses have caused many investigations into the actual conditions existing in boiler rooms, resulting in much closer attention to methods of firing and a correction of many defects in boiler and furnace settings. Possibly the most noticeable change in this connection has been a general reduction in excess air admitted to the furnace by infiltration through boiler settings.

Steam Meters.

The object in considering this subject has been to determine the value of the steam meter to measure steam supplied to turbine and reciprocating engine units. Steam meters have generally been used by small industrial concerns on heating plants, measuring steam of constant flow.

Manufacturers of steam meters state that there have been very few meters sold of 6-in. size or larger. Their principal difficulty in handling a unit of a large size is their lack of facilities for calibrating it. Most meters that have been supplied in the past require individual calibration. A great difficulty that the manufacturers have experienced with steam meters, in their endeavor to make them reliable for turbine or reciprocating engine units, has been the failure to make a meter operate accurately, because of the superheat and the presence of pulsations in the supply.

There have been two well-conducted attempts made in the past few months to make use of steam meters. One case was the application of a steam meter to a 1,000-KW., low-pressure turbine. In this particular application it was found that, owing to the very unsteady flow of steam, the meter was unable to measure it accurately, and the results were so unsatisfactory that the meter was taken out.

In the second application the meter was installed for the purpose of measuring steam used for operating air compressors. This was a 3-in. meter, and the conditions under which it had to operate were very unfavorable, as the quantity of steam taken by the compressors was only a small percentage of the indicating capacity of the meter. The results of this test, however, which was very carefully conducted, demonstrated that the meter was satisfactory, and indicated that if it had been operating near its capacity the results would have been entirely satisfactory.

Such information as we have been able to obtain shows conclusively that the steam meter has not yet been developed to the point at which it may be said to be entirely satisfactory for measuring accurately the quantities of steam supplied to large units where the steam is superheated or of intermittent flow.

Low-Pressure Turbine Plants.

The first installation in this country of turbines operated by low pressure or exhaust steam took place about four years ago, and the operating results of these first installations have been carefully followed by engineers interested in improving the economy of existing plants. Three years' operation has demonstrated that the exhaust or low-pressure turbine has fulfilled very largely the expectations of the manufacturers and designers, and the past year has witnessed a number of installations, the most important being the large machines installed in the 59th St. power-house of the Interborough Rapid Transit Co., of New York.

The low-pressure or exhaust turbine was originally designed and developed to utilize a portion of the heat in the exhaust from a reciprocating engine, which otherwise would pass into either the condenser or the atmosphere. It will thus be seen that the low-pressure or exhaust turbine is an adjunct to the reciprocating engine, and performs the function of utilizing the expansion of the steam between the limits of 15 or 16 lbs. absolute and 1 lb. absolute. Since initial pressure for this type of apparatus is practically atmospheric, it is, of course, understood that the low-pressure turbine must be operated with a condenser, and that the higher the degree of vacuum that can be maintained on this machine (other things being equal) the greater the economy that may be expected from the unit.

Reciprocating engines, on account of the enormous size of the cylinders required, do not lend themselves readily to large ratios of expansion. On the other hand, the turbine is particularly well adapted for handling the large volumes of steam which result from high ratios of expansion.

An engine working between 150 lbs. absolute and 15 lbs. absolute, or atmospheric, utilizes (roughly) 10 expansions of the steam. If an exhaust turbine be added to this unit, which will work between, say, 15 lbs. ab-

*Abstract of the report of the Committee on Power Generation at the annual meeting of the American Street and Interurban Railway Engineering Association at Denver, Colo., Oct. 4 to 8.

solute initial and 1 lb. absolute, the turbine will be utilizing 15 further expansions of this exhaust steam, and is thus able to develop in many cases as much power as the reciprocating engine itself. Were the condensers applied directly to the engine, and the steam expanded from 150 lbs. absolute to, say, 10 lbs. absolute, the number of expansions would be 15 instead of 150 expansions, as shown by the above combination. This ability to handle the large volumes that result from the higher degrees of vacuum is one prominent characteristic of this type of machine, and the fuel saving obtained is the direct result of its utilization. The mechanical efficiency of these machines is also high, and the labor account for operating them has been found to be remarkably small.

These low-pressure turbines are being installed in two classes of plants:

(1) In plants where the reciprocating engines have been operated for some years non-condensing, usually through lack of a sufficient water supply. In most cases these are plants which have been built for some years, and the exhaust turbine when used with cooling towers and condensers has proved a satisfactory means of increasing the output of the plant and improving the general economy of the station.

(2) In connection with plants which have been originally designed and operated with condensing reciprocating engines. In this case a large increase in output has been readily obtained, but the increase in economy is not so marked.

The earlier turbines which were installed in plants first noted above were connected to direct-current machines and were, therefore, of comparatively small size. The largest machines of this type that have been successfully operated are about 800 KW. The use of the low-pressure turbine, coupled with alternating-current generators and operating in parallel with other machinery of the same class, has led to the building of these machines in much larger sizes within the last year; one machine of 7,000 KW. is now in operation, and the manufacturers report others on order.

Where the machine operates in parallel with other generators in the same plant, and is electrically interlocked, a safety governor alone is necessary, and the output of the low-pressure turbine is directly in proportion to the amount of steam coming to it from the other engines in the plant.

In this connection it may be stated that the turbine may be either coupled up directly to one engine so as to form (as it were) an additional cylinder for the unit, or it may receive its supply from a header or main into which all the engines about the plant exhaust.

For either "header system" or "individual" installation, the intermediate pressure between the engine and turbine may be allowed to vary with the load, or else be maintained constant, depending upon the conditions which obtain in each installation. There is considerable advantage in having the intermediate pressure fluctuate with the load, particularly on light loads. Here the back pressure on the engines would be reduced and their economy held up noticeably, while the turbine economy would not be materially affected over that of constant pressure supply. In this way the overall results of the combination may be greatly improved.

The main object in maintaining a constant exhaust pressure is to avoid air leakage where the pipe joints or the rod and gland packing on the engines are not sufficiently air tight. If allowed to fluctuate there would be air leakage when the pressure was below atmospheric, thus reducing the vacuum. Such leakage would occur only on light loads, and the air-pump capacity being then in excess of the needs is better able to care for the greater air leakage.

The matter of air leakage is always an indefinite quantity, but in well-designed and constructed piping in modern plants should be found practically negligible. No trouble with low pressure turbines was experienced from air leakage where the exhaust pressure varied with the load and fell below atmospheric pressure.

A modification of the low-pressure turbine, known as the mixed-pressure turbine, may be noted. In this type of machine, provision is made for the use of live steam whenever the supply of exhaust steam is not sufficient to take care of the demands upon the electrical end of the machine. This is provided for either by use of separate nozzles to which the live steam is admitted, or by a reducing valve through which steam is drawn into the regular supply pipe. Mixed-pressure turbines, of course, are supplied with governing devices, and the live-steam supply is entirely under the control of the governor. The addition of this feature will increase the cost considerably and is only warranted in special cases.

It is characteristic of these machines when operated with only a safety governor that with a fixed pressure in the supply pipe the load carried will be a fixed and predetermined amount. With a variable pressure in the supply pipe the load carried by the turbine will rise as the load rises on the reciprocating engine, since the increased output of the reciprocating engine increases the quantity of exhaust, and thereby raises the pressure in the supply pipe of the turbine, thus increasing its output.

CONDENSERS.—The condenser is a very important part of a low-pressure turbine installation, and no particular type seems to have received the preference up to the present time. Good results have been reported from both surface and barometric condensers when well designed and of sufficient capacity. In all cases the connection between the turbine and the condenser should be as short and direct as possible.

COOLING TOWERS.—Where the water supply for the operation of condensers is limited, and it becomes necessary to use artificial means for cooling the water, resort must be had to the use of either cooling towers, spraying ponds or other suitable means for dissipating the heat which has been rejected to the condenser. While these devices are an absolute necessity, in many cases they tend to reduce the economy, since the operation of fans or the spraying of the water and the lifting of the water to the height of the tower, through which it falls by gravity, all consume a portion of the power generated by the machine.

Reports indicate that motor-driven fans when used on cooling towers will consume from 5 to 8% of the power of the machine, depending on the weather conditions. Natural draft towers are free from this expense, but are more expensive in first cost and require more ground space. The total power consumed in operating condensers and cooling towers appears to run from 12 to 18% of the power generated.

The more efficient the condensing apparatus the less the total loss, since it reduces both the cost of pumping the water through the tower and renders the towers more efficient on account of the smaller quantity of water being forced through them. The subject of the efficiency of cooling towers and the cost of cooling the water for condensing purposes requires thorough investigation in any particular locality, as the size and efficiency of the apparatus is largely dependent on the local weather conditions, such as average humidity of air, etc.

REGENERATORS.—Where the steam supply from the reciprocating engines is more or less intermittent it has been found advisable to install a steam regenerator, which consists of a large tank partially filled with water and connected in a line between the reciprocating engines and the turbine. The function of this apparatus is to equalize the supply of steam to the turbine, which it accomplishes by acting as the "heat fly-wheel," absorbing the exhaust steam in excess of turbine requirements and giving out to the turbine a liberal supply when the supply from the engines falls off.

Its principal use is in connection with rolling mills or engines used on similar work where the fluctuations are sudden and violent, but your committee does not find that the regenerator is an essential adjunct to low-pressure turbines used in railway work where the load on the engines is reasonably uniform. While used to quite an extent in steel mills abroad, your committee has found but one place in this country (the Wisconsin Steel Co.'s mill in South Chicago) in which the regenerator has been applied.

OIL SEPARATORS.—In some cases trouble has resulted from the absence of an efficient oil separator in the supply pipe for the turbines. In one case this accumulation of oil seriously interfered with the operation of the turbine, the cylinder oil from the engines being carried through into the turbines. Since the turbines should be supplied with clean, dry steam an efficient oil and drip separator between the reciprocating engines and the turbine is considered to be an absolute necessity. This should be located as near the turbine throttle as convenient, and careful arrangements should be made for draining this separator and keeping it in good working order.

Further advantage arising from the use of this oil separator will be found in plants using surface condensers, since the condensed water being free from oil can be used for the boiler supply, and this greatly minimizes the amount of scale in the boilers.

COSTS.—Your committee has been able to obtain only fragmentary information as to the cost of low-pressure turbines and their installation. When installed as an adjunct to an old plant, as has been the case in most instances, the changes of piping and general alterations of the plant often involve a very considerable expenditure. The turbine will range in cost, say, from $35 to $40 per KW. in the smaller sizes to from $15 to $18 per KW. in the larger sizes, which, of course, in that case are understood to be a. c. generators.

The complete installation, however, including all the auxiliary machinery, condensers, cooling towers, etc., if necessary, and including changes in building and piping, may run the cost up to from $80 to $100 per KW. in the smaller sizes, although $40 to $50 would doubtless cover the entire expense in the larger sizes.

The replies received from users of turbines indicate that exhaustive tests of economy are not available.

Hot Water Meters.*

Many experiments with hot water meters indicate that there are very few that even approximate accuracy in their indications. Those that test quite close to correct when new, rapidly fall off in accuracy and often show erratic results. The Venturi type of meter is undoubtedly the best now on the market for this purpose. (Public Service Ry. Co., Newark, N. J.)

We have used a Venturi meter with indicating manometer very successfully on water up to 212° F. The calibration of this meter was checked by means of a weighing hopper, and verified to within approximately 150 lbs. in 33,000. This shows that the Venturi meter is sufficiently accurate for any work in connection with boiler or station tests.

Discussion.

Mr. Charles Hewitt, of the Philadelphia Rapid Transit Co., stated that experiments have shown that the samples tested by flue-gas analyzers are not simply the products of combustion, but are diluted by an unknown amount of infiltrated air. Mr. B. F. Wood (Pennsylvania Ry.) said that samples taken from different points of the flue varied enormously, due to the fact that the gases were not thoroughly mixed in the combustion chamber. This might depend on the working of the boiler; if worked at low capacity, the gases might flow in strata without mixing; if worked at full capacity the mixing would be more complete. Mr. Hewitt agreed as to this. The most constant results were obtained by running the sampling pipe well into the combustion chamber, with a perforated pipe across the chamber, thus drawing gas simultaneously from various points.

As to steam meters, Mr. F. E. Case referred to a recording flow meter of the General Electric Co. It is intended to measure a constant flow, but it can be calibrated to give an accurate record on periodically intermittent flow. It would not work on an intermittent pulsating load as in a Parsons turbine.

Mr. Hewitt (Philadelphia Rapid Transit Co.) said that steam meters could be used for other work in power plants besides measuring the flow to the main units. He has tried the St. John meter on several auxiliaries with interesting results. The first test was on an air compressor for the signal system. This was a pulsating load and the compressor was so piped that the condenser condensed all the water, in order to test the meter. The meter was found to record within 3% of the weighed water, although it was working very near its minimum load. He believed that on higher loads the meter would register within 1% of the weighed amount.

As to low-pressure steam turbines, Mr. Hewitt referred to two of 800 KW. at Philadelphia. With the turbines carrying 16 to 20% of the total load of the station, the average coal consumption had been reduced from 4.4 lbs. to 3.75 lbs. per KW.-hr. Mr. Twining thought that such turbines could be built of smaller size than 500 KW., which is the present limit.

A SUBSTITUTE FOR COTTON WASTE for car-journal-box packing has been invented by Samuel A. Flower, of Bayonne, N. J. The material is made from the fiber of the cocoanut husk. It is submitted to a chemical treatment and the hard, woody portions are removed. It is claimed that in its capillary absorption and elasticity it is a superior material to the ordinary cotton waste. Tests on railway cars which have made the round trip across the continent are said to have shown better results in boxes packed with the new waste than those packed with cotton. Mr. Flower has also invented a cheap waste for wiping machinery, which is said to cost half as much as the cotton waste now used for that purpose.

ELECTRIFICATION OF STEAM RAILWAYS would be unnecessary if steam locomotives were better operated. The Canadian Pacific Ry. has issued a circular to its locomotive engineers urging greater care in the operation of locomotives. The circular is as follows:

Enginemen may become traffic solicitors by adopting advanced methods of handling engines, so as not to jolt passengers in starting or stopping their trains, avoiding reckless running and by firing lightly so as to prevent black smoke.

Some exceptionally good fuel records, equal to the average European railways, have recently been made by our engines, and if the average consumption of coal could be reduced to these special records the electrification of railways would be indefinitely postponed, because there would be no smoke nuisance, and the cost of operation by steam would be so low that the advantages of the electric railway would be removed. There is no trick in it. All that is necessary is to take full advantage of your knowledge of the district over which you are running, and of your engine.

1. Shut off steam when it is not required.
2. Regulate the feed water so that the supply will be just equal to the evaporation.
3. Fire lightly, scattering the coal well over the grate bars, so that the dust and gases from each particle of green coal will be arrested and consumed instead of being thrown out of the stack in black smoke when the engine is fired heavily.

*This subject was included in the "Question Box," and we append it here as relating to the subjects considered in the report of the Committee on Power Generation.—Ed.

A Speed-Reducing Gear for Use with Marine Steam Turbines.*

The inherent desirability of interpolating some form of reduction-gear between a marine steam-turbine and the propeller it drives has long been sufficiently obvious. Suggestions for effecting this by electrical or hydraulic means have been frequent. The straightforward solution of the problem by means of a pinion and a spur-wheel has generally been dismissed as impracticable, although the remarkable efficiency of a well-constructed toothed-wheel drive is known to all. The waste of energy in such a transmission gear is notably less than is commercially practicable with an electric coupling, which in turn is superior in this respect to the hydraulic system.

Nevertheless, the fact that turbines of the Laval type were not constructed to transmit more than some 300 HP. constituted prima facie evidence that with higher powers special difficulties were to be feared. The remarkable results obtained with motor-car drives, where tooth pressures at times exceed 2,000 lbs. per linear inch, were no sure indication that equally good results could be obtained in transmitting by gears some 4,000 HP. instead of 40, since the rule of three is by no means always applicable in practical constructive engineering. Nevertheless, in his lectures on the steam-turbine before the Society of Arts last spring, Mr. Gerald Stoney did suggest that the newer alloy steels and the greater accuracy of workmanship, which have made gearing so successful in motor-car practice, did hold out a prospect that the problem of the marine steam-turbine might be solved by means of ordinary toothed reduction-gearing.

Those interested in steam-turbines have known for some months past that a solution of the problem on these lines was, with his characteristic enterprise, being put to a practical test by Mr. George Westinghouse, who was having constructed for him a double-helical spur-gear intended to transmit 6,000 HP. at 1,500 revolutions of the pinion per minute, the reduction ratio being about 5 to 1. Through the courtesy of Mr. Westinghouse we are now able to publish illustrations of this remarkable experimental gear, the details of which have been worked out by Rear-Admiral George W. Melville and Mr. John H. Macalpine, who have patented the novel features on which they rely for success. A perspective view of the gear, with the casing partly broken away, is represented in Fig. 1, which shows the device coupled to a Westinghouse double-flow turbine. The forgings for the gears were obtained from Messrs. Krupp, of Essen, the teeth being cut by Messrs. Shuchardt & Schütte, Chemnitz, while the standing parts were made by the Westinghouse Machine Co.

The pinions have 35 teeth each and the spur-wheels 176, a hunting-cog being introduced to equalize wear. The pitch is 1¼ ins., and the pitch helices are at an angle of 30° with the axis of the shaft. One wheel and pinion have, of course, right-handed helices, and the other pair left-handed, so as to eliminate end-thrust. The diameter of the pitch circle of the large wheels is about 70 ins. and of the pinions, 14 ins. Details of the gear-box are shown in Figs. 2, 3 and 4. The gears have been designed after a long and comprehensive study of the circumstances which tend to interfere with the proper working of very broad teeth. A small pitch was deemed essential if a reasonable absence of noise was to be secured, and this necessarily meant broad teeth, in view of the fact that 6,000 HP. was to be transmitted with a pitch-line speed of very nearly 100 ft. per second, and with a limiting pressure of 453 lbs. per lineal inch on the teeth.

In order to ensure the proper working of such broad teeth, Messrs. Melville and Macalpine have adopted the plan of mounting the pinion shaft in a device which they have dubbed a "floating frame," the object of which is to cause the alinement and position of this shaft to be controlled wholly by the interaction of the teeth in contact, and not by the greater or lesser skill of the workman in laying out and fitting the bearings, which, moreover, even if exactly right to start with, could not be depended on to maintain permanently their alinement.

The "floating frame," which is lettered F in Figs. 2 to 4, is a heavy steel casting flexibly mounted in the gear-box, and supporting in rigid bearings the pinion shaft, but in such a way as to allow of this shaft having a slight longitudinal freedom, so that it can slide axially to and fro within the frame.

Fig. 2 is an elevation of the floating frame showing the flexible I-beams B, on which it is supported from the bed-plate. The pinion, it will be seen, is supported in three bearings, the center bearing dividing the tooth faces P_1 and P_2, of which P_1 is right-handed and P_2 left-handed. The large gear, being much stiffer, requires only two bearings. The floating frame is made very deep vertically, so as to be exceedingly stiff to withstand deflection by the nearly vertical forces at the bearings. It is also amply stiffened in the horizontal plane to obviate deflection from the weaker horizontal forces.

The floating frame is shown in plan in Fig. 3, while Fig. 5 shows the pinion shaft and the flexible shaft S by which it is driven. At the end of this shaft is a coupling C driven by the turbine shaft T. The axes of the gear and pinion are horizontal and parallel to one another when everything is in correct adjustment. But it will be evident that the I-beams B are virtually a hinge, and if the large gear G was not in place, or the coupling C connected, the axis of the floating frame and pinion could easily be deflected in the vertical plane through a small angle by a slight flexure of the webs.

The coupling consists of two flanges C_1 and C_2, mounted on the shafts T and S, and connected by two transverse links L_1 and L_2, and by a center pintle, care being taken not to make this restraint redundant. The shaft T can, therefore, only rotate the shaft S through the links L_1, L_2, but as these are transverse, no longitudinal forces can be transmitted. Even when seriously out of adjustment, the longitudinal forces are so small as to be negligible. The pinion, therefore, has perfect freedom of longitudinal movement in its bearings. Further, the pinion is driven by the shaft S, which passes completely through it to the end distant from the coupling, where it is keyed and bolted. This shaft is so flexible that it imposes practically no constraint on the pinion and floating frame such as would prevent slight angular yield of the I-beams B. It is evident, therefore, that, both as to its longitudinal position in the floating frame and in the angular position of its axis, the pinion is solely under the control of the forces transmitted by the teeth of the large gear.

Neglecting the very slight friction of the well lubricated teeth, the total forces at the tooth contacts, indicated by B, E and B^1, E^1, Fig. 5, will be nearly at right angles to the teeth at B and B^1; that is, they will be at 30° to the vertical. Hence the two parallelograms of forces shown will be similar. Now the horizontal forces at B D, B^1 D^1 are the only axial forces acting on the pinion. If these are not equal the pinion will at once shift longitudinally, which it is free to do, till they are equal. The two parallelograms of forces then become equal to one another in every respect, and the vertical force B F is equal to the vertical force B^1 F^1. But besides this longitudinal movement of the pinion, the frame in which it is mounted is free to rotate about the center point O by flexing the I-beams. Hence it follows that the moment of the vertical force B F about O must be equal to that of B^1 F^1 about the same point; and as B F = B^1 F^1, the arms of these levers O B and O B^1 must be equal. Thus it is claimed that not only will the total forces on the teeth P_1 and P_2 be equal, but the distribution will be so similar that the centers of pressure B and B^1 will be similarly placed.

This, it is contended, practically assures a good distribution of pressure under all conditions of load. For, by sufficient running of the gear, it may readily be assured for one particular load; and, if the pinion and floating frame are made sufficiently stiff, this condition will not be seriously changed by increase or decrease of load. The strength of both pinion and floating frame are far in excess of that requisite to sustain the maximum forces to which they will be subject, and their dimensions were made such as to give ample rigidity. For instance, under full load the flexure of the cast-steel floating frame in the vertical plane is so slight that the end bearings will be lowered relatively to the center by not more than 1/2,000-in.

There is, moreover, a certain compensation for this deflection, owing to the action of the lubricant. Professor Osborne Reynolds' researches on the action of the lubricating films in Mr. Beauchamp Tower's well-known experiments on lubrication seem clearly to indicate that at 1,500 revolutions per minute of pinion in the present gear the oil-film in the bearings will be well over 1/1,000-in. thick. When the load on the gear is increased, the end-bearings will be forced down, bending the pinion and making the teeth bear harder at the inner ends I and I^1. Thus more than the proper force will be exerted on the center bearing, and less on the outer bearings. This will at once lead to a thinning of the oil-film on the center bearing, and to its thickening on the outer bearings. As the total thickness of the oil-film is more than twice the yield of the outer bearings, this change in the thickness of the film will go far to compensate for the elasticity of the floating frame.

Given that the axes of the gears are parallel to start with, the action of the teeth will, it is claimed, force the axis of the pinion into exact alinement with that of the large gear, provided that in the flexure of the I-beams supporting the floating frame the pinion shaft tilts in a vertical plane parallel to that containing the axis of the large gear. If there were no floating frame, and all bearings of the pinion and gear were cast in one bed-plate, the longitudinal dimensions remaining unchanged, an error of alinement of the axes in the vertical plane not exceeding 1/1,000-in. in the length over the bearings would entirely upset the uniform distribution of the pressure along the faces of the teeth. Hence, with the most careful work, the above assumptions may not be fulfilled with sufficient accuracy. Even if they were exactly fulfilled when the gear was first completed, inequality of the side wear of the bearings might cause the axes to stand at a sensible angle in the horizontal plane.

Provision is made for measuring such errors of alinement, as follows: Outside the end bearings of both pinion and gear, as shown at g_1, g_2, g_3, g_4 in Figs. 2 and 3, there are vertical and horizontal gages placed so that errors of alinement can be readily measured when the gear is running. If the horizontal gages at g_3 should show the axes too close by, say 1/10-in., and those at g_4 should show them too open by 1/10-in., giving a total error of alinement of 1/5-in. in the length between the gages, it may be shown that, with involute teeth, which are here used, they will bear hard at I and I^1, Fig. 2, and lightly at J and J^1. If the teeth were perfectly rigid, there would, of course, be point contacts at I and I^1, and the teeth would actually stand open by a small amount at J and J^1. This opening Messrs. Melville and Macalpine call the "opening of contact."

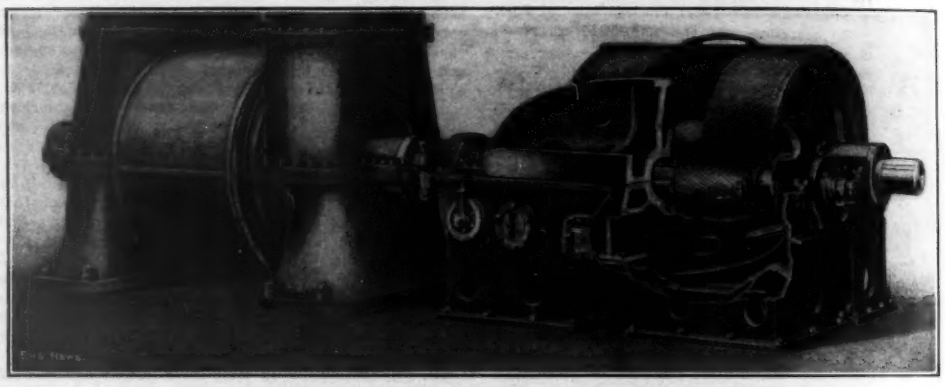


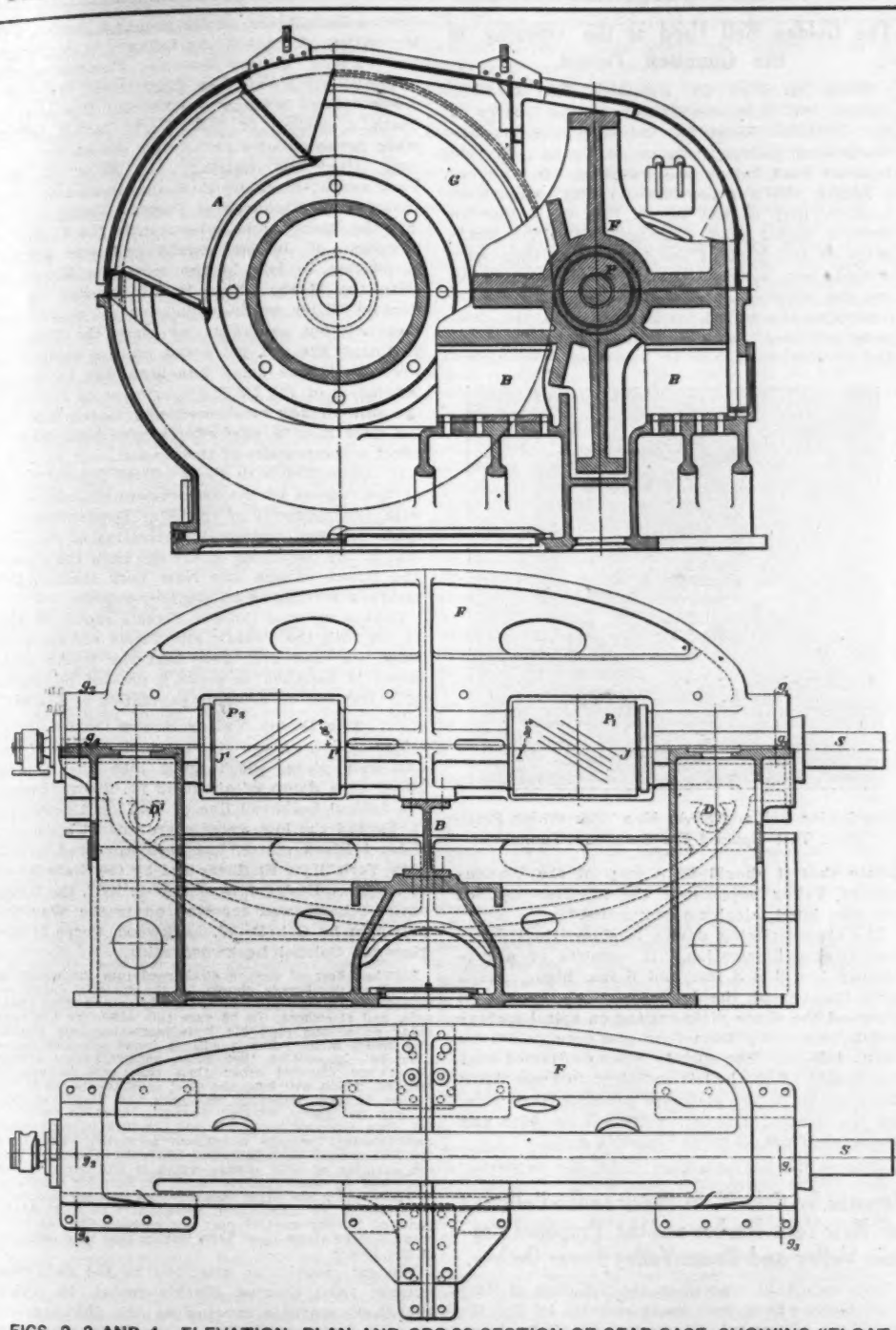
FIG. 1. A SPEED REDUCING GEAR FOR MARINE STEAM TURBINES.
(Invented by Admiral Geo. W. Melville, Past-President Am. Soc. M. E., and John H. Macalpine.)

If in changing from perfect alinement the pinion turned about either a vertical or a horizontal transverse axis, it may readily be shown that the opening of contact would be a considerable fraction of the sum of the errors shown by the end gages. On the other hand, the inventors state that the action of the floating frame in combination with involute teeth is such as to constrain the pinion to turn about an axis parallel to what is known as the line of action of the teeth—in the present case, an axis inclined 14° 30′ to the vertical—and this is precisely the movement which reduces the opening of contact to a minimum.

The result is shown in Fig. 6. The error of each end gage is indicated by the horizontal scale, the total length representing 1/10-in., corresponding to a total error of alinement in the horizontal plane of 1/5-in. between the gages, as explained above. The vertical scale shows the "opening of contact" if the teeth are rigid, this scale being enormously magnified, as the quantities to be represented are so small. The curve A B represents the resultant opening of contact for given gage errors for the present gear. The extreme opening of contact shown is 1/6,500-in., and this for a gage error which should never be approached. At half this gage error, still large and easily measurable, the opening of contact is reduced to one-quarter of the foregoing, or 1/25,000-in., a quantity far below the limit of accuracy of the very finest machining.

Consider next the effects of the elastic strains of the teeth and shafting. Steel gears of 1¼-in. pitch are commonly run under a load of 1,000 lbs. per inch of tooth face at ordinary pitch-line speeds. As all gears are liable to errors of alinement, this average pressure actually means that at time there will be a maximum pressure very much greater. In the gear under discussion the highest mean value used is less than 500 lbs. per inch of tooth contact. Suppose then that by errors of alinement the actual value varied from zero to 1,000 lbs. per inch, which is far within the disturbance occurring in ordinary gears. It may be shown that the yield

*From "Engineering" (London), Sept. 17.



FIGS. 2, 3 AND 4. ELEVATION, PLAN AND CROSS SECTION OF GEAR CASE, SHOWING "FLOATING FRAME" CARRYING PINION SHAFT BEARINGS.

of these teeth under 1,000 lbs. per inch is such that the distribution of pressure would close up an opening of contact of nearly 1/1,000-in. Thus, even under the extreme gage errors shown at B, Fig. 6, Messrs. Melville and Macalpine claim that the disturbance of distribution of contact pressure is comparatively slight, and at half the gage error stated it would be insensible. They claim therefore that gage errors of sensible magnitude do not produce a sensible disturbance.

Errors of erection will be exceedingly minute, so that the only errors to be avoided are those due to unequal horizontal wear of the bearings. Any unequal vertical wear will be compensated for by slight tilt of the floating frame. As the forces on the floating frame are inclined to the vertical at only a small angle, vertical wear will take place much more quickly than horizontal; and as the inequality of the wear will usually be but a small fraction of the total wear, it would be almost impossible for any very sensible angular error in the horizontal alinement, such as assumed above, to creep in before the bearings were worn down a long way vertically, and ready for renewal. The case they state is very different if the floating frame is dispensed with, and all the bearings are cast in one bed-plate. The worst supposition is that there is an error of alinement of the axes in the vertical plane. Keeping all dimensions of the gear and bearings the same as in the gear already built, the resulting "opening of contact" is, they find, shown by curve A C, Fig. 6. This exhibits extreme sensitiveness to this error of alinement, as allowable limits will be passed before each vertical gage shows an error of 1/1,000-in. Such an error would be so small as to be quite insensible to the eye, and would arise even from strongly screwing down one of the holding-down bolts, or from slight heating of the bearings, and could not be avoided by the most perfect workmanship. Hence the gear with rigid bearings they hold to be quite impracticable.

Involute teeth have been used, as they give the excellent results shown by the curve A B, Fig. 6. But they have also the well-known property that if, through wear of the bearings or errors in the original setting up, the axes are somewhat farther apart than designed, the teeth still run true, and there is no "opening of contact." This does not hold with any other form of teeth. For instance, with epicycloidal teeth the action will not be true if the centers move apart, the axes remaining parallel; and in these fine high-speed gears a recession of the centers not exceeding 1/1,000-in. would, the designers assert, be quite serious. With this form of teeth also, when the alinement is defective, an opening of contact of 1/1,000-in., supposing the teeth rigid, corresponds to an error of each end gage of 1/100-in.—that is, a total error of alinement between the gages of 1/50-in., which could hardly be detected.

Besides, on account of the way in which openings of contact occur with epicycloidal teeth, the limit of allowable opening of contact is, it is claimed, much under 1/1,000-in. Hence this form of tooth is far inferior to

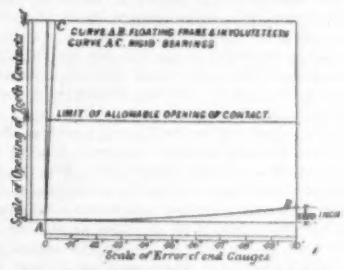

CURVE A B, FLOATING FRAME & INVOLUTE TEETH
CURVE A C, RIGID BEARINGS
LIMIT OF ALLOWABLE OPENING OF CONTACT
Scale of Opening of Tooth Contacts
Scale of Error of end Gauges

Fig. 6. Curves Showing Limits of Error in Alinement of Gear Teeth.

the involute on account of its extreme sensitiveness to errors of alinement, and also from the fact that it will not run properly when the axes part even slightly, so that the stresses would be much intensified, and the action of the teeth would be noisy. The curve A B (Fig. 6) is tangential to the base-line at A, while for all other arrangements and forms of teeth the curve of opening of contact cuts this base-line at an angle. Hence the solution presented by the floating frame with involute teeth is unique.

From the foregoing it will be seen that the elasticity of the I-beams allows freedom of movement of the axis of the pinion and floating frame in the vertical plane. But by warping the webs of these beams the axis of the

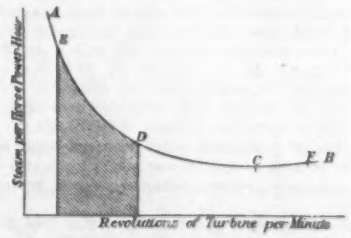


Fig. 7. Curve Showing Relation Between Rotative Speed and Steam Consumption of Steam Turbines.

floating frame might also turn slightly in the horizontal plane. It is, of course, many times more rigidly mounted against this displacement than against that in the vertical plane, but still the rigidity is by no means complete. Now it may appear that this is not specially important, as from curve A B, Fig. 6, it would seem that such an angular displacement in the horizontal plane, even if of measurable amount, causes no important disturbance. But that is not the only consideration, as the question then arose as to whether with freedom of rotation both in the vertical and horizontal planes the position of the axis of the floating frame would be stable or unstable; that is to say, if forcibly displaced from exact alinement to a small angle in the horizontal plane, will the forces at the tooth contacts tend to bring it back to perfect alinement or to further displace it? By consideration of the slight changes of direction of the forces at the tooth contacts produced by such displacement, it can readily be shown that, with involute teeth, the position of the axis of the floating frame is unstable,

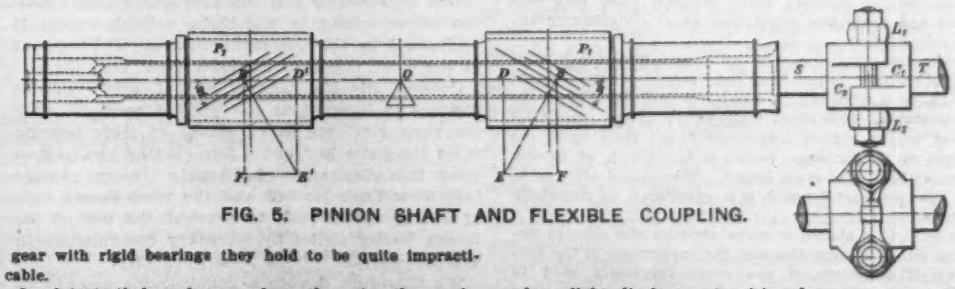


FIG. 5. PINION SHAFT AND FLEXIBLE COUPLING.

and a slight displacement arising from any cause will tend to increase. With the I-beams alone, therefore, there might arise excessive horizontal errors of alinement, and trifling causes might produce sudden and violent changes of the horizontal error, either of which effects would endanger the whole mechanism. The floating frame has therefore been deprived of all freedom of

motion in the horizontal plane by means of two horizontal struts standing transversely between the floating frame and bedplate. These bear on the floating frame at D and D^1, Fig. 2, and one is clearly shown in Fig. 1. Obviously these struts in no way interfere with the freedom of movement of the floating frame in the vertical plane. Where they bear in the bedplate there is an adjusting and locking mechanism which greatly facilitates the true setting up of the floating frame, and is to be seen in the perspective view in the front of the bedplate, near the end next the turbine.

With epicycloidal teeth in perfect adjustment, the position of the floating frame axis can be shown to be stable without struts. But this is only an apparent advantage, as this stability would at once be upset by widening the gear and pinion centers, or by the slightest wear. But even if this stability could be trusted, it is believed that epicycloidal teeth are far too sensitive to errors of adjustment to be used, and the question of stability or instability in no way affects this consideration.

The only condition which would cause serious disturbance of the tooth pressures is an excessive heating of the pinion above the temperature of the gear. But the design provides for a copious application of lubricating and cooling oil, especially to the pinion, which has most tendency to heat. The cover, also, is so arranged as to draw in air at the ends and at A, Fig. 4, by the fan action of the gears, and discharge it by openings (not shown) to the right of this cross-section. Besides, water can be circulated, by means only partly shown in the figures, between the pinion, and the flexible shaft S. But it is not anticipated that the heat to be removed per minute will be so great as has been provided for. The gears of heavy electric trains work under much higher stress both in the metal and between the teeth in contact—very much higher, as these stresses are accentuated by errors of alinement shown by rounding of the teeth through wear—and with practically no lubrication. Yet they run for long distances. In the reduction-gear these unfavorable conditions are reversed—there is good lubrication and very uniform contact. If the coefficient of friction at the tooth contacts is 1/10, it can readily be shown that the friction loss at the teeth will be under 1%. So that even if the gear were transmitting 6,000 HP.—the very highest power hoped for—this frictional loss would be under 60 HP. As at least one-half will go to the large gear, where it will readily be dissipated from the large surface, there is left well under 30 HP. to remove from the pinion, which, with the various means provided, should present no difficulty. If then this control of the heat is assured, there will, it is claimed, be practically perfect tooth contacts; this, with the fine pitch and the spiral gears (avoiding sudden entering or leaving contact of one whole tooth at a time), will, it is asserted, ensure reasonably quiet running of the gears.

At 1,500 revolutions per minute of pinion and 453 lbs. per inch of tooth contact, the gear will transmit 6,000 HP. The pitch-line speed would then be 5,500 ft. per minute, and the mean speed of sliding about one-tenth this, or 550 ft. per minute. There is on record a case of a right-angled worm-gear run successfully at 15,000 ft. per minute with a contact pressure of 350 lbs. per inch. The average speed of sliding will here be greater than the pitch-line speed by over 41%, or, say, 21,000 ft. per minute. Taking speed of sliding multiplied by pressure as a rough means of comparing these two cases, we get:

$$\text{Reduction gear} \quad \frac{5{,}500 \times 453}{\text{Right-angled worm gear} \quad 21{,}000 \times 350} = \frac{1}{20.5}$$

The extreme constants chosen, therefore, seem well within practical limits.

As already stated, at 7,500 revolutions per minute of pinion, and 453 lbs. per inch of tooth contact (or only 45% of the intensity of pressure for similar teeth at ordinary pitch-line speeds), the gear will transmit 6,000 HP. If this be realized, similar gears could be applied to any speed of ship. This design would then be of the correct power for the "Dreadnought," and applied to her would save fully 50% of the weight of her turbines, besides reducing boiler weights, since both turbines and propellers would now be of considerably enhanced efficiency.

Increasing, by the law of comparison for similar machines, the dimensions and power of the present design, from 6,000 HP., a size is obtained suitable for the "Mauretania" with three large screws of the same total power as the present four-screw ship. Here again the weight of the turbines, would, it is claimed, be halved, as also the engine-room length. The boilers also, as in the "Dreadnought," would, it is considered, be materially reduced.

In Fig. 7 is plotted a curve showing the relation between steam consumption and the revolutions of the turbine. The portion of the curve frequently used in marine practice is hatched, and shows clearly how very rapidly the efficiency falls off as the speed diminishes. By using gearing it is contended that the turbine at maximum power can be even slightly overspeeded, as at F, so that at cruising speeds the efficiency will actually be increased.

The Golden Bell Used at the Opening of the Gunnison Tunnel.

When, on Sept. 23, President Taft formally opened the Gunnison Tunnel to the waters of the Gunnison River for the supply of the Uncompahgre Valley Reclamation Project, the old familiar push button was not used. In its place a golden bell was provided for him to place on a silver map of the valley. By his action an electric signal was transmitted to the headgates at the inlet of the tunnel and they were immediately opened. As it was necessary to use the wires of the Colorado Telephone Co., in conveying the signal to the headgates, the company provided the circuit-closing apparatus for the President's hand. It was considered appropriate that it should be a map of the Uncompahgre Valley supporting the familiar sign of the associated telephone companies.

The Golden Bell and Silver Map With Which President Taft Opened the Gunnison Tunnel.

The circuit-closing device is shown in the accompanying illustration. It consists of a mahogany box 6 × 8 ins. and 6 ins. high. Flush with the top of the lower part of the box is mounted the silver plate resting on spiral springs which hold it up from four platinum points by about 1/16-in. The springs are so adjusted that the weight of the bell is sufficient to press down the plate upon the platinum contacts, thus closing the circuit. The bell itself is 3 ins. high and was made from 18-karat Colorado gold.

Reports by Col. W. M. Black on the Pollution of New York Harbor and the Proposed Passaic Valley and Bronx Valley Sewer Outlets.

Two important reports on the pollution of New York Harbor have been made recently by Col. W. M. Black, Corps of Engineers, Chief Engineer Officer Department of the East (Army Building, New York City). The first one was dated June 21, 1909, and dealt with both the proposed Passaic Valley sewer outlet into the harbor at Robbins' Reef and the Bronx River Valley outlet (now under construction) into the Hudson River at the New York-Yonkers city line. The second report is dated Oct. 4, and relates to harbor pollution in general, and the proposed Passaic Valley sewer outlet in particular. Each report is addressed to the Adjutant General, Department of the East, Governor's Island, New York City.

Colonel Black's reports are of great significance and interest at the present moment, both for their contents and because of their bearing upon the suits brought a few months ago to prevent the discharge of Passaic Valley sewage into New York Harbor and the more recent suit, actual or threatened, to prevent the use of the Bronx Valley outlet by tributary communities in Westchester Co., above New York City.

We therefore devote a considerable amount of space to these reports, particularly to the one of Oct. 4.

Before taking up the reports it may be noted that in our issue of Dec. 17, 1908, we published a report of a public hearing before the New York Harbor Line Board, on the proposed Passaic Valley outlet. This hearing followed a request of the Passaic Valley Sewerage Commission for authority from the War Department to build a sewer tunnel beneath the Newark Bay and beneath a portion of New York Harbor and to place sewer-outlet structures in the harbor. Not long after the hearing, the State of New York sought from the U. S. Courts an injunction against the discharge of Passaic Valley sewage into the harbor, and subsequently the U. S. Department of Justice sought and was granted permission to join in the suit. On March 25, 1909, the Harbor Line Board reported on the Passaic Valley sewer application (as quoted further on), but so far as we know the War Department has not yet acted on the application. Presumably the delay has been due to the intervention of the U. S. Department of Justice in the suit already mentioned, and to the fact that for some months past efforts have been made to effect a compromise of the lawsuit.

In connection with these efforts Colonel Black, at the request of the Department of Justice and with the approval of the War Department, has made a comprehensive investigation of the relation of the discharge of sewage from the Passaic and Bronx valleys into New York Harbor, thus virtually serving as an engineer-referee.

Taking up now Colonel Black's report of June 21, on both the Passaic and Bronx sewage problems, we may first note that the Bronx outlet sewer is designed to serve a present population of 50,000, but an ultimate population of 850,000.

The Bronx Valley Sewer Outlet.

The outlet, at the start, would consist of two cast-iron pipes, discharging into the Hudson River at a depth of about 42 ft., 236 ft. beyond the federal bulkhead line of 1897, and about 170 ft. beyond the low-water shore line. This outlet, Colonel Black states, has been approved by the New York State Engineer and by the State Board of Health. Under date of Feb. 2, 1907, the Bronx outlet scheme was reported on to the War Department by Col. D. W. Lockwood, Corps of Engineers. Colonel Lockwood said:

5. The effect of sewage discharged into the waters of New York Harbor is shown by the material being removed at the New York end of Ambrose and other channels, and elsewhere. To be sure this discharge has been going on a long time but it is increasing very rapidly and before many years it will be found not only desirable but imperative that some comprehensive system of sewage disposal other than that now in use be adopted, which will keep the solid constituents out of the harbor besides rendering innocuous the liquids allowed to run as now.

6. The proposed sewer will add but little to the present unsatisfactory sewage conditions prevailing, and from the best sources of information available, it appears that the quantity of solid matter which it will carry to the river will be comparatively small, at least for a number of years. It is therefore recommended that no objections be raised to its installation, particularly as it would be included in any general plan for reorganizing the sewerage system about New York Harbor that may come up in the future.

We call particular attention to the following extract from Colonel Black's report, in which the U. S. statutes bearing on the discharge of sewage and more solid wastes into navigable waters is quoted and legally interpreted:

The question was then submitted to the Judge Advocate General of the Army, who gave a lengthy opinion dated March 14, 1907. The Judge Advocate General quotes Sec. 13, Act. of March 3, 1899, as follows:

Sec. 13. That it shall not be lawful to throw, discharge, or deposit, or cause, suffer, or procure to be thrown, discharged, or deposited either from or out of any ship, barge, or other floating craft of any kind, or from the shore, wharf, manufacturing establishment, or mill of any kind, any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state, into any navigable water of the United States, or into any tributary of any navigable water from which the same shall float or be washed into such navigable water; and it shall not be lawful to deposit, or cause, suffer, or procure to be deposited material of any kind in any place on the bank of any navigable water, or on the bank of any tributary of any navigable water, where the same shall be liable to be washed into such navigable water, either by ordinary or high tides, or by storms or floods, or otherwise, whereby navigation shall or may be impeded or obstructed;

and concludes as follows:

In view of the exception in favor of matter entering the navigable waters through sewers "in a liquid state" which is embodied in the acts of 1890 and 1899, it is the opinion of this office that the effect of the language used is to take the case of matter flowing from sewers in a liquid state out of the operation of the prohibitory clauses of the statute. In other words, Congress in legislating to forbid the deposit of matter in the navigable waters, exempts from the operation of the prohibition matter which flows into such navigable waters from streets and sewers in a liquid state and, by so doing, relegates authority to control such outflow to the con-

stitutional authorities of the State in which the drainage plans are executed.

It may be conceded that such flowage may, at some time in the future, so diminish the capacity of the navigable waters as to make it necessary for Congress to interfere, with a view to protect the interests of navigation, but from the absence of such language at present I think the conclusion must be reached that it was not the intention of Congress in the act of March 3, 1899, to interfere with the flowage from sewers into New York Harbor or its adjacent waters.

The application to the Secretary of War, it appears from Colonel Black's report, was "to extend the Bronx Valley Sewer into the Hudson River beyond the established bulkhead line," and was in no direct sense a request for a permit to discharge sewage into the river. The application was referred to Colonel Black's office on May 20, 1909, but, to quote again from Colonel Black's report of June 21, 1909:

On May 28, 1909, the Attorney-General of the United States wrote to the Secretary of War stating that an original suit was about to be begun in the U. S. Supreme Court by the United States against the State of New York and the Bronx Valley Sewerage Commissioners, for the purpose of restraining the construction and operation of the Bronx River Valley sewer and the discharge of sewage therefrom into the waters of the Hudson River and the upper and lower New York bays, and suggesting that it may be to the advantage of the Government if action upon the application to extend the sewer into the Hudson River is deferred at any rate until negotiations for the possible settlement of the controversy may have been had.

No further action on this application has been taken, in so far as this office is informed.

Colonel Black then discusses at some length the general question of the pollution of New York Harbor, methods of sewage treatment available and related matters. At the conclusion of his report he returns to the Bronx outlet sewer, as follows:

24. That the volume of water in the Hudson is sufficient to care ultimately for the flow of the Bronx Valley sewer is believed to be true, but it is not believed that the untreated sewage can be poured continuously into the river at a single point without creating a local nuisance.

25. A tank sufficient to contain the total outflow for one day with the present population, and therefore sufficient to allow facilities for screening, sedimentation and septic action would have the following dimensions: 200 ft. × 125 ft. × 40 ft. Such a tank can be constructed without undue cost. If, in addition to this the effluent were aerated by forcing air under pressure into the outflow pipes, and these pipes so arranged as to distribute the effluent in deep water over a comparatively large area, through numerous outlets, it is my opinion that the sewage can be discharged safely and without nuisance.

26. As the population enlarges new tanks can be added, the permit being given under the condition that the effluent shall always have a given minimum standard of purity.

27. It is further probable that within a few years the state of the art will have advanced to a point which will enable the sewage to be so purified by processes more simple than those known to-day.

The Passaic Valley Sewer Outlet.

NEW YORK HARBOR LINE BOARD REPORT ON PASSAIC SEWER OUTLET.—We have reserved for insertion here the following important portion of Colonel Black's report of June 21, 1909.

7. Under date of March 25, 1909, after a lengthy hearing of all parties interested, including sanitary engineers, the New York Harbor Line Board, comprising Colonels Lockwood, Ruffner, Knight and Roessler, Corps of Engineers, submitted a report on the proposed Passaic Valley sewer project, and recommended as follows:

(1) That the tunnel under Newark Bay shall be constructed so as to give a clear depth of not less than 35 ft. at mean low water in the navigable channel;

(2) That the sewage shall be sedimented and screened on the Newark side of the main channel in accordance with such plans as the Sewerage Commission of the State of New Jersey, or its legal successor, may hereafter submit and the Secretary of War approve;

(3) That the Sewerage Commission shall at any time when so required by the Secretary of War, make such modifications in the screening and sedimentation plant as will insure the purification of the sewage to the standard which the State or City of New York may hereafter adopt and enforce as to sewage entering into New York Harbor from sources within the territorial limits of the State of New York;

(4) That the gate house near Robbins' Reef Light be erected at the point and under such plans as the Secretary of War, after consultation with the Secretary of the Department of Commerce and Labor, may hereafter approve;

(5) That the Passaic Valley Sewerage Commission shall remove from the waters of New York Harbor any shoals when the Secretary of War shall be satisfied that the same result from the discharge from the proposed tunnel, and shall direct their removal.

Colonel Black's report of Oct. 4, 1909, first gives a summary of observations made by him on visits to Boston and Washington, to see the effects of sewage disposal by dilution. The report also contains a general discussion of recent advances in and the present status of sewage treatment. An important section deals with the present and prospective pollution of New York Harbor. Finally, Colonel Black gives his conclusions as to the conditions under which the Passaic Valley sewage might be allowed to be discharged into New York Harbor.

SEWAGE DISPOSAL BY DILUTION AT BOSTON.—We first quote descriptions of screens and general methods of sewage disposal of Boston:

2. On Aug. 26 and 27, in company with Mr. Hugh Gordon Miller, Special Assistant to the Attorney-General, I inspected the sewage disposal plant at Boston. On the 26th, we had a long interview, first with Professors C.-E. A. Winslow and Earle B. Phelps, of the Massachusetts Institute of Technology, in charge of the sewage experiment station of that Institute at Boston, and later with Mr. William M. Brown, Jr., C. E., Chief Engineer and Superintendent, Metropolitan Sewerage Commission. Later we visited the Commission's pumping station at Ward Street and inspected the sewage screens at that station. These screens are of the ordinary lift type and 10 ft. wide by 10 ft. high. There are two sets of two screens each, one screen of each set being lifted for cleaning while the other is in use. The screen proper consists of a series of 3-in. round iron bars, placed vertically, parallel to each other, and with a clear space between of 15/16-in. In the lower two-thirds of the screen, a second series of bars, of the same size and spacing, is placed about 1 in. in front of the first series, with the bars opposite the spaces of the first series, so that a clear space between the two bars, measured on a line at right angles to the direction of the flow, is about 3/16-in., but the clear space between the bars, measured diagonally to the flow, is about one inch. The screens have to be cleaned about once per hour during dry weather flow; during storms cleaning must be at 10-minute intervals. All of the larger floating bodies are caught by these screens. The screens are cleaned by hand, and the materials caught are formed into cakes under hydraulic pressure, and burned in the boilers of the pumping station. The material caught seems to be mainly rags, paper, fruits, etc.; occasionally bodies of small animals and even of infants are found. The material intercepted by the screens at the north metropolitan sewage stations is equivalent to 2.8 cu. ft. per 1,000,000 gals. pumped at Deer Island. The material intercepted at the south metropolitan sewage station amounts to 4.3 cu. ft. per 1,000,000 gals. sewage delivered at the outflow works at Nut Island. The characteristic odor of stale sewage is plainly evident at the pumping station.

3. On Aug. 27, accompanied by Mr. Brown and Prof. Phelps, we visited the works in the harbor in a boat kindly furnished by the courtesy of Lieut.-Col. Edward Burr, Corps of Engineers. The point of the discharge of the sewage from the city proper, at Moon Island, was first visited. The discharge here is made at ebb tide, reservoirs having a capacity of 50,000,000 gals. being provided for storage between the times of discharge. The discharge is made on the surface of the water, and amounts to about 80,000,000 gals. during each ebb. The sewage is somewhat stale and has partially sedimented in storage, as well as having been subjected to coarse screening. The sewage floats on the top of the water, and covers an area which, in extreme cases, is as great as 2,000 acres. The presence of the sewage in this area is plainly evident by the odor, by an oily appearance of the water surface (sleek) and by the color and presence of particles of sewage.

4. We then went to the point of discharge of the South Metropolitan System at Nut Island. Here two lines of 60-in. cast-iron pipe are carried over the bottom from Nut Island to west of Peddock's Island, and discharged in depths of 30 ft. at mean low water (40 ft. at high water). At present only one pipe is in use at a time, and through it 40,000,000 gals are discharged daily in a continuous flow, with a maximum discharge of 140,000,000 gals. The discharge takes place through a single opening, pointed upward. At the time of the visit, just about high water, the characteristic sleek covered an area of about 500 ft. sq., in which the water was discolored, and with fine particles of sewage material, each distinctly visible. There was a slight odor perceptible. The sleek was distinctly visible and clearly defined. The tide at that time had begun to ebb, with a surface velocity of about 2 or 3 miles an hour, and a bottom velocity of about 3 to 4 miles.

5. The point of discharge at Deer Island was then visited. The end of the sewer is visible at low water, the discharge being in 10 ft. of water at high tide. The discharge is continuous and has an average of 50,000,000 gals. per day, with a maximum of 150,000,000 gals. At the time of our visit, about an hour after high water, the effluents were visible from the surface over an area of 50 to 150 ft. wide and about one-half mile long, discoloration, the presence of sewage particles, the odor, and the characteristic sleek being plainly perceptible.

6. Later we visited the experiment station of the Boston Institute of Technology, situated at the pumping station, South Boston, and saw the experimental septic tank and sprinkling filters. . . .

SEWAGE DISPOSAL BY DILUTION AT WASHINGTON, D. C.—Omitting a brief description of the experiment station just mentioned, we continue to reprint the report, as follows:

8. On Sept. 2, accompanied by Mr. Miller, I inspected the Washington sewage disposal plant. The pumping station here is described as the finest in the world. The sewage is passed through a screen similar to that in Boston, but, being fresh, there is very little odor. It also passes through a sediment chamber, 50 ft. wide by 104 ft. long, which is cleaned once in from two to four weeks, the average amount removed each time being ————, which represents the solid contents removed from about 1,386,000,000 gallons of sewage, and about ———— per million gallons. After leaving the pumps and before entering the siphon, it passes into a skimming tank, 16 ft. × 24 ft. in area, where bodies floating on the surface are removed, by means of a long rake. A very large part of these floating bodies is composed of match sticks, and these seem to gather the grease from the sewage, which is thus removed along with the sticks. The point of discharge is in the Potomac River, between Washington and Alexandria, in water about 28 ft. deep. The discharge is through two outlets. The water is fresh, and the diffusion of the sewage in the water was much more perfect than was noted in Boston. At the time of our visit, it was difficult to find the exact point of discharge from surface indications. The water was very slightly discolored, a very slight odor was perceptible. The color of the river water being nearly the color of the sewage, close observation was necessary to observe the floating particles. The area discolored was about 30 ft. wide and 250 ft. long.

9. Thanks are due to Captain Markham, Acting Engineer Commissioner of the District, and to Mr. A. E. Phillips, Engineer-in-Charge of Sewers, for many courtesies received.

10. A fact of importance was clearly shown from the above-mentioned inspection, namely, that in the Potomac River, the discharge being in fresh water, the sewage was rapidly diluted and speedily lost in the volume of flow, and the color of the Potomac water being nearly the same as the color of the particles of sewage matter, the visibility of these particles was slight, whereas in clear sea water, of the usual light green tint, the dispersion of the sewage in the general body of water took place much more slowly and the color of the sewage being markedly distinct, its presence was conspicuous. Another interesting fact is the absence of the characteristic sleek from the Potomac at the point of discharge. This is supposed to be due to the removal of the grease with the match sticks from the skimming tank.

NEW YORK HARBOR POLLUTION.—After mentioning conferences with Messrs. Rudolph Hering, Edlow W. Harrison, and John W. Gregory, Engineers of the Passaic Valley Sewerage Commission, Colonel Black proceeds to discuss conditions affecting New York Harbor:

12. New York Harbor is now receiving untreated sewage from Greater New York, as well as from cities in New Jersey bordering the harbor. The sewage from this population is many times greater than that proposed to be delivered from the Passaic Valley system, which last is now being emptied into Passaic River, a tributary of the Bay.

13. The tributaries of New York Bay, including East River (in which the volume of ebb flow into the bay much exceeds the volume of the flood from the bay), together with New York Bay, form the natural means of drainage for all of the population lying within their watersheds. The amount of uncontaminated water entering the upper bay is large, that from the sea alone, through the Narrows, having been estimated by Mr. Allen Hazen at about 3,000,000,000 cu. ft. daily (22,440,000,000 gals.) and to this should be added 836,000,000 cu. ft. (6,254,000,000 gals.), the daily excess of the ebb discharge of the East River over that of the flood, which is mainly supplied from the uncontaminated waters of Long Island Sound. This daily renewed supply of fresh water is sufficient to care for the sewage of the present population of the areas emptying into the bay, without danger to health, were it possible to distribute this sewage in such a way that each gallon of it should immediately receive its proportional amount of dilution with uncontaminated water. This dissemination is manifestly impracticable, since the sewage must reach the drainage basin through a limited number of points. Up to the present, no effort has been made looking to this end. Such distribution of the sewage as exists is purely accidental, and due to the sewer outlets having been constructed along the shores, at the points most conveniently situated for the service of the area drained by each. As a result, at different points along the shore of the bay, the waters of the harbor are locally polluted, ranging from an imperceptible amount to the septic tank conditions found in Gowanus Canal.

Conditions similar to this last exist at times in the Passaic River, to the detriment of the communities living along its shores, and therefore to the general detriment of New York itself, to the commerce of which all of these communities contribute. *The project presented by the Passaic Valley Sewerage Commissioners is really the first attempt on the part of any of the communities tributary to New York to better these conditions. It would be manifestly unjust to impose upon the communities trib-*

utary to the Passaic Valley sewerage system, requirements for sewage purification which would not be practically applicable to the communities residing in other areas which drain into New York Bay. [Italics ours.—Ed.]

14. The evil result of discharging sewage into the waters of the bay may be considered under various aspects; first, in the contamination of the waters caused by pathogenic bacteria; second, pollution by the undue reduction of the oxygen in the waters of the bay; and, third, the pollution appreciable to the sight and smell, but not necessarily dangerous to health.

15. The question of the necessity for the removal of pathogenic bacteria from the sewage effluent has been carefully considered abroad, and, to a certain extent, in our own country. It has been found that the most effective ways, if not the only effective ways practicable, for effecting the removal of bacteria from the sewage, are either by sand filtration or by chemical treatment [disinfection—Ed.], the best being probably the latter, using hypochlorite solution. It has been found by experiment in this country that by the use of commercial hypochlorite an ordinary crude sewage effluent can be practically freed from bacteria at a cost not to exceed $4 per million gallons. As stated by Mr. George W. Fuller in a lecture delivered at Cornell University in May, 1900, the necessity for undergoing this expense is an economical problem, which has to be settled by each community in accordance with its needs. In Germany this complete purification is not insisted upon, even in the case of sewage poured into the Rhine at points above the water-supply intakes of towns lower down the river, although provision is made for such purification in the case of epidemics. The German authorities content themselves, in general, with a rigid disinfection in the houses of the patients suffering from infectious water-borne diseases and with a careful filtration of water-supplies. On the other hand, the city of Baltimore, Md., is incurring great expense for the bacterial purification of its sewage, since the effluent from this city is discharged into Chesapeake Bay in the neighborhood of extensive oyster beds, which are one of Maryland's sources of wealth.

In the case of New York Harbor, the waters are nonpotable, and are not used for domestic purposes. The dangers arising from bacterial pollution are mainly those incurred by persons bathing in the water and by pollution of shellfish grown or fattened in the Arthur Kill, on the shores of Staten Island, of Sandy Hook, and of Gravesend Bay. *The shellfish industry is quite extensive, but, in all, its value is slight as compared with the cost of bacterial purification of the sewage poured into the harbor. Since these waters are additionally contaminated by surface washings from all of the populated areas surrounding the harbor, even bacterial purification of all sewage would not render the waters safe. It would seem that the wiser course would be to prohibit the shellfish industry in these waters.* [Italics ours—Ed.] In addition, the best authorities agree that pathogenic bacteria multiply but little when removed from the human body, and that their life in uncongenial surroundings is comparatively short, so that the effect of pouring bacterially contaminated waters into New York Bay is not cumulative, in so far as the pathogenic bacteria are concerned. It would be manifestly unjust to require bacterial purification of the sewage from the Passaic Valley system without making a similar requirement for all sewage entering into New York Harbor and this seems economically unnecessary to-day.

THE SEWAGE TREATMENT PROBLEM.—16. The reduction of sewage to a stable and unoffensive form, apart from its sterilization, is essentially a process of oxidation. The ordinary crude sewage of American cities contains about 800 parts of solids per million gallons. Of these solids, about 60 to 70% is in solution, the remainder in suspension. About one-half is organic matter, and one-half mineral. The division of the organic matter is about equal between the dissolved and suspended material (Winslow and Phelps, Purification of Boston Sewage).

17. When sewage is left out of contact with the air, it putrefies, and this process is accompanied by the formation of noxious odors. Under conditions which admit of the rapid absorption of oxygen, it nitrifies, or, in other words, becomes oxidized, without the production of foul odors. When poured in water, it is oxidized slowly, the oxygen necessary being taken from surrounding water and from that contained in the sewage itself. When the amount of oxygen in the mixture of pure water and sewage is reduced below 50% of the normal amount of oxygen contained in pure water, the mixture becomes offensive. The aim of modern treatment is to make these processes inoffensive, either by a complete purification of the sewage before its final disposal, or by a partial purification and disposal in a volume of water great enough to receive safely the dose of sewage. No exact measure of the amount or dilution necessary is known, but it is generally conceded that if each cu. ft. of ordinary sewage is diluted with at least 16 cu. ft. of pure water, the mixture will be safe as against offensive putrefaction. In practice, however, the actual dilution must be much greater than this, since uncontaminated water cannot be found, and the amount of oxygen in the available supply will be subject to marked variations. In addition, before water is reduced to a technically offensive state, it has reached a condition so far from limpidity as to be undesirable and destructive to the higher forms of fish life. In Chicago, the dilution required by law is twenty-fold. It is reported that no complaints are made of offensive conditions resulting from this degree of pollution, but the exact conditions of this mixture as to limpidity and the effect on fish life are not known. Winslow states that the dilution must be fifty-fold in order to be safe.

18. There are objections to a pollution of a waterway to a degree appreciable to the eye and nose, quite apart from the danger to health. Shipping naturally objects to the use of such polluted waters for an anchorage if that can be avoided. The popularity and use of a passenger steamboat route using such waters is also seriously affected. The objections may be termed sentimental, but they are none the less real and have an appreciable effect in dollars and cents. They are most appreciable when the route lies partly in limpid and partly in polluted waters, or, in other words, where a local pollution exists, the contrast forcing an annoyance on the senses, which might be otherwise unnoticed. Such local pollutions exist in Boston Harbor at the points of discharge of the main sewers. Fortunately for Boston, they are somewhat aside from the routes followed by vessels.

19. The improvement made in recent years in the processes of sewage purification by bacterial agencies may be appreciated from the statement that by the original process, that of broad irrigation, the amount of sewage which could be purified per acre per day does not exceed from 30,000 to 50,000 gals at a maximum. With this, for American towns, an acre would be required for each 300 to 500 of population, while with the modern sprinkling filter (so-called), the quantity of sewage which can be treated per day per acre of beds, has risen to from 2,000,000 to 2,500,000 gals., which at the same rate, would care for a population of from 20,000 to 25,000.

20. The sprinkling filter is not really a filter. It is an oxidising machine using bacteria as an agent, in which the effluent carries away practically all of the sewage poured in it, but with the organic matter oxidized, and in a form which settles from the fluid rapidly. The broad irrigation process was developed into a process using septic tanks with the effluent oxidized in contact beds, with or without later filtration. By increasing the volume of voids in the contact beds, and providing for the aeration of the sewage, by having it fall in drops on the beds, together with provision for the entrance of air into the voids in the beds, the sprinkling filter was evolved, and it was found that with its use the prior septic tank treatment is unnecessary.

21. Dibdin has gone further than is the general practice and increases the contact areas, while diminishing the useless interior volumes of the stone in the beds, by the use of slate. It would seem to be but a step further to substitute for the beds of stone a tank provided with grids of metal or slate through and between which the sewage would flow slowly, and to aerate by introducing air under pressure at the bottom of the tank in such a manner as to have it rise through the liquid gently and in small bubbles.

Experiments have shown that aeration will increase the amount of dissolved oxygen in polluted water. In one experiment the increase was from 9.5% to 52.4% of saturation; in another from 36.3% to 50.5%. In 1900, analysis of water taken respectively above and below the bear trap dam at Lockport, Ill., showed that the aeration produced by the flow over the dam had increased the dissolved oxygen from 5.9% to 70% of saturation. (Lederer, First Report Lake Michigan Water Commission.)

22. Unfortunately, experiments in aeration of sewage have not been carried far enough to show whether such a process would be effective in practical use in sewage purification. It is possible that a process similar to that outlined above might so much increase the efficiency of the oxidizing machine as to reduce the area required for sewage treatment to a degree which would make it suitable for use in thickly populated districts. For such centers of population the areas conveniently available are too restricted to permit complete sewage purification by other known processes excepting at too great a cost. Usually such congested centers are situated near flowing water and it is the modern practice under these conditions to take advantage of this natural reduction agency to the extent which the volume of the daily supply of uncontaminated water will warrant. Generally it is found that a partial purification is necessary before discharge. This is effected by sedimentation and screening.

23. The solids in sewage are partly in suspension and partly in solution. In addition, a comparatively large amount of sand and heavy matter is rolled along the sewer bottoms, and floating bodies are carried on the surface. In the simplest treatment, similar to that in practice in Boston and Washington, the heavier particles are removed in small sediment chambers and the larger substances, floating on the surface or held in suspension, are caught by coarse screens of round bars, set about 1 in. apart. The resulting effluent is turbid, and putrescible, and contains much matter in suspension. No purification is effected beyond the removal of such coarse materials as might injure the pumps.

24. When discharged in a large volume in sea water, the sewage rises to the surface rapidly, and in Boston Harbor it forms what must be termed a local nuisance. It is claimed that by making the discharge through small orifices in deep water, distributed over a large area, the sewage will be so diluted when it reaches the surface as to be practically unnoticeable. An argument presented in support of this theory is derived from an experiment made by the Engineers of the Passaic Valley Sewerage Commissioners in New York Harbor, in which it was found that highly colored water, lighter than sea water, when released at depths exceeding 10 ft. below the surface did not produce any appreciable surface discoloration. The deduction is not strictly applicable, since the coloring matter used was in a finely divided form and the particles were rendered visible by their contiguity. Hence the colored water was capable of dilution to an extent sufficient to separate the colored particles far enough to render each invisible. This would not occur when the suspended particles are of a size which renders each visible, as in sewage. Dilution would increase the distance between the suspended particles, but would not render them invisible.

SCREENING AND SEDIMENTATION.—27. For partial purification, fine screens and lengthened sedimentation are necessary. Kuichling has calculated that grains of sand of 0.004-in. in diameter will sink in still water at a rate of 1.6 ft. per sec., and that grains of 0.01-in. in diameter will sink at the rate of 6.5 ft. per sec.; that to secure settlement of grains of sand of .004-in. in diameter in a fluid 10 ft. deep, the length of the settling chamber and the velocity of flow must be such as to require 10 mins. for passage of sewage through it, so that if the mean velocity of flow is 2 ins., the length of the chamber must be 100 ft. Winslow and Phelps state on this subject as follows:

> The line of demarkation between the so-called detritus (sand, etc.) and the remaining suspended solids, or sewage sludge proper, is rather sharply marked by the rapidity with which the particles settle. One class of material will settle out in a very few minutes when the velocity is still considerable and the other will settle only when the liquid is practically at rest and in the course of hours rather than minutes. According to figures given by Robinson (1896) a velocity of .5-ft. (6 ins.) per sec. will not move fine clay and .7-ft. (8.4 ins.) will just move coarse sand. Hence it may be stated that detritus may be removed from sewage at any velocity less than the former figure. On the other hand, sedimentation of the true suspended sludge necessitates a slackening of velocity to .1-ft. (1.2 ins.) per sec. or less. In London settling basins velocities of 0.07-ft. (0.84 ins.) per sec. are maintained; at Manchester, 0.05 (0.6 in.); at Saltley and Sutton 0.03 (0.36 in.); and at Frankfurt a. M. 0.01 to 0.02 (0.12 to 0.24 in.). Steurnagel (1904) found that velocities less than 0.07-ft. (0.84 in.) permitted as complete sedimentation as was possible with absolute rest, but that 0.13-ft. (1.56 ins.) were too great. Again the time required for sedimentation is considerably different in these two classes of material. Detritus being largely sand will settle out in a very few minutes; but the remaining solids require a much longer time for sedimentation. . . . Steurnagel studied the same phenomenon (laboratory experiments in sedimentation) in a deeper layer (2 meters) and found the removal of suspended organic matter to be 42% in 5 mins., 61% in 25 mins., 75% in 6 hrs., and 80% in 24 hrs. (Purification of Boston Sewage, p. 116.)

26. In the Columbus, Ohio, experiments, it was shown that with a current velocity of from 0.016 to 0.0217 ins. per sec. in a tank 40 ft. long with the sewage 7.5 ft. deep, the percentage of removal of the suspended matter varied from 42 to 68%. In a report to the International Waterways Commission, dated December, 1906, Messrs. Hering & Fuller state that the amount of suspended matter which can be removed by sedimentation from Chicago sewage is 65% or of total organic matter 30%.

27. Fuller, in his Cornell lecture of May 4, 1909, says:

> Speaking generally, from 50 to 65% of the suspended matters in well screened sewage can be removed by sedimentation in basins holding 6 to 12 hours' average flow.

28. Kuichling states that if the preliminary operations of the grit chamber and screens are limited to the extraction of the heavier and coarser matters only,

> it was found that by letting the sewage remain in the tank about 12 hrs. a maximum of 90% of the total dried suspended matter was removed at Frankfurt, 83% at Cologne, and 74% at Chemnitz. . . . From careful observations made at Cologne and Hanover with tanks varying in length from 120 to 230 ft., it has been established that with a velocity of about 1/6-in. per sec., or .8-ft. per min., a length of 130 to 150 ft., and, hence, a period from 2¾ to 3¼ hrs. for passing through the tank, the largest quantity of sediment consistent with economical construction will be attained, and these figures are now generally adopted in Europe as standards for securing effluents by sedimentation which can safely be discharged into relatively large streams without further purification. (Kuichling, Proceedings, 34th Annual Meeting New Jersey San. Assn., Dec., 1908, p. 120.)

29. It is probably safe to say that to make any effective removal of organic matter from sewage by sedimentation, the velocity in the sediment chamber must not exceed 1 in. per sec. and that for this velocity the relation between the length of the chamber and the depth of liquid must be such as to allow time for the particles heavy enough to settle at this velocity to reach the bottom. If the experiment of Steurnagel be taken as a criterion, 5 mins. are required for the settlement of 42% of suspended matter in a still fluid through 6.56 ft. On the other hand, to secure practically the same per-

centage of removal as that given by Steurnagel, 42%, the Columbus experiment showed that for a tank 40 ft. long, with sewage 7.5 ft. deep, 6.6 hrs. retention in the tank was necessary, or a velocity of 0.0217 in. per sec. At higher velocities, certain of the suspended matter will not settle at all.

30. When sewage is retained for 6 hrs. in a tank at low velocity, it would seem that a certain amount of septic action must take place. This seems to be the case in the Birmingham sedimentation tanks with 4 hrs. retention, where the dissolved solids in the effluent were increased by the tank 2½%. (Purification of Boston Sewage—Winslow and Phelps). . . . In this connection, Winslow and Phelps may be quoted pertinently again. They state:

Under the term sedimentation is included septic treatment, since the septic process is really plain sedimentation with the additional anaerobic fermentation of the sludge produced. Such a process seems to combine the best features of all the preliminary treatments thus far proposed, since it effects an adequate removal of suspended solids with no expense for chemicals and produces a minimum of sludge. Furthermore, the actual removal of suspended solids is somewhat greater with the septic tank than with plain sedimentation, from the solution of particles too small to settle easily. The only disadvantage of septic treatment is that if it be too prolonged changes may be set up which make subsequent treatment difficult. The problem is to combine the maximum liquefying action with the minimum production of toxic substances. If that can be done, the septic tank offers in general the best solution of the problem. (Purification of Boston Sewage, p. 119.)

31. When an effluent is to be discharged in large volume into a navigable waterway, the advantage of a clear effluent is apparent. The septic tank will produce this at a minimum of cost and in a minimum of area required for the treatment. It is unfortunate that sufficient experiment has not been made on the effects of aeration of septic effluents to show whether or not such aeration would remove the deleterious features of the effluent. Such a process, if successful, would go far toward solving the troublesome problem of sewage disposal in congested districts.

32. The use of screens in sewage purification has been developed most in Germany, with reported excellent results. At Hamburg the screen is made of aluminum bars set 10 mm. (.39-in.) apart. The Frankfurt screen has also 10 mm. openings. At Cologne two sets are used, the first screen has intervals of 15 mm. (.59-in.) and the second of 3 mm. (.12-in.). In all cases these screens are used in connection with grit or sediment chambers. The effluent after treatment is discharged into fresh water and it is reported that when discharged it is not noticeable.

33. Kuichling reports that at Wiesbaden three sets of screens were used, the first with bars spaced .6-in. apart, the second was formed of perforated plates with openings of .2 to .125-in. wide, and the third of perforated plates with openings .04-in. in diameter. He calculates from the data given that the screens intercepted about 66% of the suspended organic matter. Difficulty having been encountered in cleaning the screens, a new set was substituted in which the first screen was composed of bars spaced 1.6 ins. apart, and the holes in the lowermost screen enlarged to .05-in. and .07-in. It is stated that the new screens could be cleaned much more easily and that the quantity of intercepted matter was increased about 15%. He adds:

Much seems to depend, however, on the composition and manipulation of the sewage, as the experiments made at Marburg in 1897 with three sets of large screens formed of thin bars respectively .6, .25, and .06-in. apart indicated that about 40% of the suspended material in the sewage was removed in the outset; but later observations after the sewers had been more extensively used by the public (pop. 20,000) showed a considerably smaller percentage of removal by the screens. (Proceedings 34th An. Meet., New Jersey San. Assn., p. 117.)

Fuller states:

At Plainfield, N. J., when the sewage has a strength of about 90 gals. per capita daily, screens with a clear space of about .5-in. remove from 5 to 6 cu. ft. of screenings per 1,000,000 gals. . . . It is clear that ordinary weak American sewages as a rule do not readily permit of as thorough screening as strong European sewages, and that European data can scarcely be applied to American conditions with safety.

34. The Plainfield removal reported above is about 5% of the suspended matter and is but little more than that removed from the Boston sewage by the coarser screens described earlier in this report.

35. At Columbus, Ohio, two screens of .25-in. vertical rods set with .25-in. intervals were tested and found too coarse. After some trials, screens of diamond mesh wire cloth, woven with No. 12 wire, were adopted. The first screen had clear openings of .5-in. and the second of .375-in. The sewage before passing through these screens had had the coarse and heavy materials removed by a screen with .5-in. intervals. The volume of sludge caught by the second set of screens averaged 300 lbs., or 4.6 cu. ft. per 1,000,000 gals of sewage—about 2½% of the suspended matter.

36. Hering & Fuller estimate that with fine screens (30 mesh or finer) 15% of suspended matter or 10% of organic matter can be removed from Chicago sewage. (Report to International Waterways Com., Dec., 1906.) Such screens would have openings of about .02-in.

37. It is evident that to make any effective removal of organic matter by screening, the clear openings must be less than .4-in.

EFFECT OF SEWAGE DEPOSITS ON NAVIGATION.—38. In an earlier report, it was shown that the amount of decrease of depth in a navigable waterway due to sewage deposits is usually so small as to be negligible if the discharge is so arranged that the deposits are made over an extended area. And as an example, it was stated that, if the untreated sewage from the Passaic Valley sewer were poured into the bay and deposited over an area one mile square, the thickness of the annual deposit would be about one-tenth of a foot.

Sewage deposits form but a portion of the solid materials entering these waters and probably a small one, the deposits caused by surface drainage from the surrounding lands and by materials brought into the bay by its tributaries being probably greater. Dredging will always be required from time to time in those portions of these waters in which the natural conditions favor the deposit of the water borne materials. *The cost of such dredging is smaller than the cost of the works necessary to free waters entering the bay from the suspended matter. Where local deposits are clearly formed by materials brought in public service sewers or gutters, they should be dredged at the public expense.* [Italics ours.—Ed.]

39. *In considering the conditions under which the Passaic Valley sewage can be permitted to enter the bay, the shoaling effect in the navigable channels may be disregarded, provided that the discharge is so arranged as to prevent a local accumulation.* [Italics ours.—Ed.]

SUGGESTED CONDITIONS FOR DEGREE OF TREATMENT AND DISCHARGE OF PASSAIC VALLEY SEWAGE.—40. It is proposed to make the point of discharge of the Passaic Valley sewer in water at least 40 ft. deep off the Robbins' Reef Light, and to distribute the discharge over an area of at least 3.5 acres. From other data given, it is evidently proposed that this area shall be approximately 400 × 380 ft. The area in question is situated near the west edge of the main ship channel, which there has a width of about 4,600 ft. between 24-ft. contours, of 3,400 ft. between 30-ft. contours, and of 2,200 ft. between 36-ft. contours. It lies just north of the entrance to the Kill von Kull. It is evident that it is directly in the course taken by deep draft vessels entering and leaving the harbor and also in the course of ferry boats running to the north shore of Staten Island, and of shipping passing between New York and the north shore of Staten Island, Bergen and Constable points, and towns on Newark Bay and its tributaries. It is one of the most traversed areas in the Harbor. Under these circumstances, it is evident that the conditions of sight and smell existing at the points of sewage discharge in Boston Harbor should be inadmissible.

41. In my opinion, sewage discharged at the point in question should be such as to fulfill the following conditions, as being the most stringent that the present state of the art of sewage purification render economically practicable under the conditions found, for the Passaic Valley Sewerage System:

(a) That the sewage effluent before discharge shall be purified to such an extent as to contain in a putrescible condition not more than 75% of the organic matter found in average American sewage, as described by Winslow and Phelps on pp. 13 et. seq. of their report of Investigations in the Purification of Boston Sewage, published as Water Supply and Irrigation Paper No. 185, of the U. S. Geological Survey.

(b) That no solid materials shall be present in the sewer at the point of discharge excepting as matter in suspension and that the particles of solid matter then in suspension shall be so small as not to be clearly noticeable when the sewage in a diluted form has reached the surface of the water near the point of discharge.

(c) There should be no escape of noxious gases at the surface of the water at the point of discharge.

(d) No sleek should be apparent at the point of discharge.

(e) The discharge should be so distributed as to cause no apparent discoloration at the surface of the water.

(f) It should be further stipulated that should the sewer be built and operated under these or similar conditions, the Passaic Valley Sewerage Commission or the other officials legally charged with the construction and operation of the said sewer system should, whenever so required, furnish to the proper official or officials of the United States designated by the Secretary of War, such expert and other assistance as the representatives of the United States may deem necessary to determine whether the conditions are being complied with.

42. In considering the above conditions, it is my belief that the proposed form of stipulation [proposal for compromise of suit—Ed.] should be altered. In its present form, it recites certain general processes proposed and then recites certain results to be obtained by these processes. It is not certain that the methods even as vaguely outlined in the stipulations will produce the results. The preceding discussion of the question would indicate that the screen as specified is too coarse and that the proposed velocity in the sedimentation chamber is too great. It would appear that the greatest reliance is placed by the Commissioners on the method of discharge. I am not convinced that the wide distribution proposed will do more than cause the sewage to appear on the water surface in a more dilute condition than is the case when discharged through a single orifice. In addition, it is believed that the partial screening and sedimentation as stipulated will do but little in reducing the volume of putrescible matter in the sewage and hence will cause a greater drain on the oxygen in the bay waters, and consequent pollution, than is desirable, when the question of the entire volume of New York Bay sewage is considered.

43. Inasmuch as the Passaic Valley Sewerage Commissioners are not to-day prepared to submit detailed plans of the works proposed and also desire to be able to take advantage of future advances in the science of sewage purification, it is perhaps best that the processes should not be now described in detail, but that certain results only should be prescribed.

44. I would recommend that conditions "A" to "F" inclusive as given in paragraph 41 be inserted in the stipulations in lieu of those originally proposed [as a basis for a compromise—Ed.] The method by which the Commissioners can be compelled to live up to such an agreement if now entered into, is a legal question to be determined by the legal advisers in the case.

45. In concluding this report, I desire to make acknowledgment of the valuable assistance given by the Consulting Engineers of the Passaic Valley Sewerage Commissioners, Messrs. Rudolph Hering, E. W. Harrison and John H. Gregory. I would also beg to state that my investigations show clearly the need of further experiment in methods of sewage disposal for congested districts such as New York and as to the conditions of New York waters respecting sewage disposal, concerning which the available information is surprisingly incomplete. The final solution of a question of this magnitude should not be attempted without funds sufficient to provide for expert assistance and limited experimentation.

Feeder Lines and Conductors for Electric Railways.

High Tension Feeders.

Underground high tension cables have passed the experimental stage, and are giving satisfactory service in a large number of installations. The majority of the later installations have been made with paper insulation. The highest voltage of which the committee have knowledge is 25,000, and this is rather the exception than the rule. From 11,000 to 13,200 seems to be the most popular range of voltage.

Where high tension circuits are used for overhead transmission lines the committee recommends steel supports in the form of towers where the line is isolated, and when along the tracks to be supported from extensions to the structure that support the trolleywires. The length of span depends on the elastic limit of the conductor, the conditions of the weather and other local conditions. All steel towers should be galvanized.

Some special conditions demand the use of wood poles instead of steel towers; for instance on streets where the line must be carried along the sidewalk, and in climates where wood is not subject to decay.

It has been found in some cases where steel towers are used, they have acted as lightning rods, and as the insulator was the highest point, it was often shattered by lightning. By substituting for the old form of insulator, a suspended type, the lightning naturally strikes the steel of the tower or a grounded cable strung from tower to tower, in preference to the insulator.

When wood poles were used, the length of the span was limited by the length of the poles securable, whereas, the length of the span can be made anything reasonable by steel towers, as these towers can be built of any reasonable height. With the new form of suspension insulator, and with 10 ft. of vertical separation between conductors, the use of wood poles for even ordinary spans is out of the question when ample clearance between lowest conductor and foreign wires or even the earth is maintained.

In the country through which long distance transmission lines are usually run, there are frequent grass fires that are liable to burn off wood poles at the ground. Occasionally nearby forest fires jeopardize the whole pole when of wood. The steel pole is practically invulnerable to such attacks in its cleared right of way. If wood construction were to be attempted on a scale corresponding to that of the steel tower, the cost would probably exceed that of the steel tower and would last only eight or ten years, whereas the galvanized iron tower should last indefinitely. As steel towers consist of many separate pieces which are only assembled when at the point of erection, it is easier to transport a tower piece-meal to a location difficult of access than it would be to transport a wooden pole of equal height.

Several different kinds of towers are inevitable on a long line; standard towers for straight line work, special towers for transpositions, heavy towers for turns and ends, tall towers for long water crossings, short towers for ridges depending on the topography of the route, etc. The length of most economical towers and span is also a problem in itself, some light on which can be gathered from the article by D. R. Scholes, on page 1221 of the Proceedings of the Am. Inst. E. E. of 1907, entitled "Transmission-Line Towers and Economical Spans."

POLE TREATMENT.—Poles should be treated at and near the groundline. (See paper by Mr. J. M. Nelson, U. S. Forest Service, Washington, D. C.)

The open tank and brush treatment of poles is more practical than the impregnating process, on account of the small investment required for equipment. It seems to be a well-developed fact that treatment must only be applied to a well-seasoned pole. If poles are set while green, treatment should not be applied until a considerable time after setting, giving the poles chance to season. Poles that are already set can be treated by removing the earth 18 ins. below the ground line and treating the surface of the poles about 18 ins. below and 18 ins. above the ground line. This process should be gone through after the first dry season, and repeated occasionally during the life of the pole.

A difference of opinion exists in reference to the use of concrete around wooden poles. Good results, however, have been obtained in San Francisco by means of concrete setting, poles having been in service 14 years set in concrete and are still in good condition. These poles, however, were of redwood, which is not available in all parts of the country. The character of the soil also should govern the decision as to whether or not treatment is necessary.

REPAIR OF POLES.—The principal trouble with old poles is at the ground level, where the moisture corrodes iron poles or rots wooden poles. In selecting a method for repair, the essentials are: (1) it must be done by common labor; (2) no special tools should be required; (3) the trouble should eliminate entirely any further corrosion or rotting of the pole; (4) the repairs should be permanent, i. e., no further maintenance would be required; (5) when completed the poles should be as strong as when new; (6) the cost must be low.

One method (applicable to metal poles only) consists of filling the inside of the pole with grout in which steel rods are bedded. Another method (applicable to wooden poles only) consists of driving U-shaped rods around the pole at the point where the timber has been rotted away and then surrounding this space with concrete.

A third method, applicable either to wooden or metal poles, consists of placing metal clamps or sleeves and bolting these together. A fourth method, also applicable to either metal or wooden poles, consists of a metal sleeve either of pipe section or split, depending on the number of fixtures on the pole. This sleeve is of a larger diameter than the pole, and is placed over the corroded or rotted portion of the pole, and the space between is filled in with some material.

In the first method, the diameter of the pole being fixed, in order to obtain the desired strength of the original pole, computation shows that such considerable amount of steel is necessary to bed in the grout, that the cost becomes almost prohibitive. With less rods only part of the original strength is obtained. The concrete being entirely enclosed, it takes a very long time for it to set; in the meantime, if the pole is badly corroded, and as the corrosion is all the time going on and increasing on the outside, the pole is liable to bend or collapse; further, the swaying and vibration of the pole is liable to loosen the bond between the concrete and the metal, and therefore the strength is greatly decreased. To avoid this, the wires must be disconnected, thus throwing out of service the poles for a long period of time, which could not always be done.

It has also been found from actual experience that in the winter time, when the metal of the pole shrinks, the inside plug of concrete does not permit of such a shrinkage, and the pole splits. There are known instances in which such poles split the entire length. The pole itself continues to corrode on the outside and in course of time some other method must be applied on the outside to eliminate the trouble.

The second method would appear to be quite effective on wooden poles, but it has not been tried a sufficient length of time to prove its efficiency. It would appear that the concrete surrounding the pole must shrink away from the wood, thus permitting water to percolate and a further rotting of the portion repaired.

The third named is quite costly, as the clamps have to be very heavy to be efficient, and even then, being held by bolts, the latter in time may become loose and corroded, and it requires constant inspection and maintenance. At best it is only temporary. It also does not stop the further corrosion of the weak spots.

The fourth method seems to be the most efficient. It is applied at the spot where the trouble originates, and entirely eliminates further corrosion or rotting. It is permanent in its nature. It brings the pole to its original strength, and, as a matter of fact, poles that have been tested with such sleeves have stood a greater stress than new ones. It looks well and neat in the street. And finally, its cost is the lowest.

This method is especially efficient when the filling material is introduced in a molten state, e. g., molten brimstone. In making this repair, some sleeves have been filled with grout, but this method is not recommended by the committee. There is one eminent point in this method which must be understood and borne in mind, and which makes the method different from the rest. In filling the sleeve with the molten material it expands considerably more than the pole; first because it is of a larger diameter, and then also on account of its temperature being higher, for the heat in the pole is conducted away up and down the pole. When this expanded sleeve shrinks, it grips the filling and the pole, and they all become one complete structure.

Last year your committee made special mention of steel construction for supports, calling special attention to steel bridges which had just recently come to the front. The art of building steel bridges for this purpose has been considerably improved during the last year, and the first cost of bridges for ordinary double track, interurban electric service has been somewhat reduced. This committee recommends the use of steel bridges for supports for use on private right of way. We present a cost comparison which will clearly show the advance that has been made in the last year.

For comparative purposes, the costs are taken, first for a mile of double track construction for heavy interurban electric service for three types of construction, ordinary trolley, catenary with wooden pole supports and catenary with bridges.

The comparison has been confined to the type of interurban or suburban electric railway work, where current is collected by means of wheel trolley, as all terminal problems, city problems, four-track or yard problems must be considered as special cases, and should be treated accordingly in looking up the cost of any form of construction. It must further be remembered that in these comparisons the figures cover only the support of a working conductor. All feeder or transmission line fixtures or wires are excluded from the costs shown, as these items would be affected by the class of service and local conditions.

COMPARATIVE COSTS OF OVERHEAD TROLLEY (SPAN AND BRIDGE) CONSTRUCTION PER MILE, DOUBLE TRACK.

Ordinary Span.		Catenary Bridge.	
Supports (Poles, Spans, Hangers, Ears)	$1,085.00	Supports (Bridges, Messenger, Suspenders, Clamps)	$1,760.36
Conductor	1,089.60	Conductor	1,089.60
Insulators	48.00	Insulators	18.30
Miscellaneous	214.50	Miscellaneous	143.40
Labor and tools	1,323.10	Labor and tools	1,407.10
Total	$3,760.20	Total	$4,418.76

COMPARATIVE COSTS OF OVERHEAD TROLLEY (CENTER POLE). CONSTRUCTION PER MILE, DOUBLE TRACK.

Catenary Wood Center Pole Bracket.		Catenary Steel Tower Bracket.	
Supports (33 Poles, Brackets, Messenger, Suspenders, Clamps)	$726.26	Supports (Towers, Brackets, Messenger, Suspenders, Clamps, Anchor Bridge)	$1,280.36
Conductor	$1,089.60	Conductor	$1,089.60
Insulators	36.60	Insulators	18.30
Miscellaneous	117.57	Miscellaneous	112.00
Labor and tools	1,032.00	Labor and tools	1,230.07
Total	$3,002.03	Total	$3,730.33

Discussion.

Mr. H. H. Stannard (New York Pole Co.) did not agree with the criticisms as to reinforcing steel poles with concrete. Mr. Martin Schreiber (Newark, N. J.) thought that the treatment of wooden poles should be confined to a band 3 ft. wide, starting at 2 ft. from the bottom of a 22-ft. pole and 5½ ft. from the bottom of a 50-ft. pole. In the tank treatment, an objection is that the bottom of the pole absorbs too great a quantity of the preservative. The cost of the brush system is about 5 cts. for labor and 20 to 30 cts. for material, so that an additional life of 1½ years would pay for the treatment. The tank treatment by his company costs $1.50 to $2 per pole, so that an additional life of six years is required to pay for the treatment.

Mr. W. G. Matthews, Superintendent of Line, Denver City Tramway, said that in 1904, his company began treating its poles with carbolineum by the brush treatment. He painted 30-ft. poles with a 6-in. brush, commencing 4 ft. from the ground and painted 3 ft., getting anywhere from ⅛-in. to ¼-in. penetration. The telephone company had built a 20-mile line and had treated each alternate pole in this manner. After five years it was found in most cases that the poles laid in concrete had dry rot from ¼-in. to ¾-in. on outside all around, while the treated poles had not started to rot. The tramway company has treated something like 1,300 poles for renewals and new construction, aggregating about 40 miles in all.

The company tried two other ways to find out if there was any better method. It has several miles of heavy feed line with 40-ft., 45-ft. and 50-ft. poles; it put 6 ins. of concrete around the pole the entire depth of the hole and crowned on top to throw the water away. These poles are as good as when they were set (1902). To find out whether it is necessary to go to that expense, on another line the hole is made only large enough to get the shovel in, with concrete 3 ft. below the surface and built up with a concrete cone around the pole. The rotting is usually from 2 ft. below to 6 ins. above the ground.

Specifications for the Interlocking of Drawbridges.*

At least one lever, called the bridge lock lever, shall be assigned for the purpose of locking the bridge.

The bridge lock lever, when reversed, shall be arranged to lock the bridge in the closed position and to prevent the application of power for the purpose of withdrawing the bridge latch or opening the bridge.

The bridge lock lever, when normal, shall be arranged to lock all levers used for bridge protection in the proper position to protect the bridge, and also to cut off power from all control wires leading to such functions.

A preliminary-locking arrangement shall be provided for each of the following purposes when signals are clear:

(1) To insure that the bridge is in proper alinement.

(2) To insure that all bridge surfacing devices are in their proper positions.

(3) To lock each rail in proper position for train movement.

(4) To prevent the application of power for the purpose of withdrawing the bridge latch or opening the draw.

The Strang Gasolene-Electric Motor Car.

The Strang motor car for railway service was described in Engineering News of March 8, 1906. Since that time the development of the car has been steadily going forward. Four cars have been built on this system, three of which are in operation on the Missouri & Kansas Interurban Ry., a 20-mile line between Kansas City and Olathe, Kan., of which Mr. W. B. Strang, the inventor of the car, is chief owner. The fourth car, which was completed in March, 1908, has been used for exhibition and demonstration purposes, and has been exhibited in most of the railway centers east of the Mississippi River.

In the Strang system, the car is driven primarily by a gasolene engine which is directly connected to an electric generator. Current from this generator is delivered to two motors mounted on the front truck of the car in the same manner as in ordinary electric railway practice. A storage battery placed beneath the car floor aids the generator when the car is starting or ascending a steep grade, and is recharged when the car is running on a level or a down grade. At starting, current from the storage battery is used to drive the generator as a motor, and the engine is driven by the generator until regular explosions begin.

The gasolene engine and its appurtenances have been made practically automatic in operation, so that the person driving the car has little more responsibility than the driver of an electric car.

The latest and largest car built is 56 ft. long over the body and 62 ft. long over the bumpers. A space about 12 ft. long at the front end is partitioned off for the engine-room, and the remainder of the car and the rear platform are available for passengers. There is seating capacity for 50 to 60. The car is built with a steel under-frame, and the engine is so well balanced that no vibration is felt from it when the car is running. The total weight of the car is 114,000 lbs.

The gasolene engine is of 150 HP. and is a 6-cylinder vertical machine driving an 85-KW. generator. The two car-motors are of 100 HP. each. The battery has 112 cells and 300 ampere-hours capacity. The automatic devices controlling the battery limit the demand upon it in such a manner that great durability and low cost of maintenance are secured.

The car can maintain a speed of 50 miles per hour, and has been run up to 65 miles per hour. By reducing the speed it has practically un-

*Embodied in the specifications for mechanical interlocking and electro-pneumatic interlocking, presented by committees at the annual meeting of the American Signal Association at Louisville, Ky., Oct. 12 to 14. These requirements may be considered in relation to the discussion of drawbridge protection in the editorial on "The Protection of Trains on Railway Bridges," in our issue of Sept. 9, 1909.—Ed.

limited power for climbing grades, as the power consumption of the motors falls off when the speed of the car is reduced, while the gasolene engine and generator maintain constant speed and full output. It can also haul trailers when necessary. Sufficient gasolene is carried on the car for a 200-mile run. The gasolene consumption varies from 0.5 gal. to 1 gal. per mile, according to the grades and frequency of stops. On one occasion the car made a run of 350 miles in one day, from Altoona, Pa., to the Strang Co.'s shops at Garwood, N. J. These shops were formerly owned by the C. & C. Electric Co., but have been acquired by the Strang Co. for the purpose of constructing the engines, generators and motors for its cars. The offices of the Strang Co. are at 15 Wall St., New York City.

Automatic Power Signals and Pipe-Connected Signals.*

A sub-committee of the Committee on Mechanical Interlocking was appointed to report on the advantages and disadvantages of using pipe-connected home signals without slots, pipe-connected slotted signals and automatic signals at interlocking points. The sub-committee has carefully considered various classes of interlocking plants now in vogue, and has divided them into three classes, as follows:

(1) Interlocking plants at passing sidings, junctions, terminals, grade crossings, drawbridges, etc., on single-track lines where block signals are not in use and not contemplated. (2) All interlocking plants where automatic block signals are now in use or contemplated. (3) Interlocking plants principally for yard movements, etc. It is understood that there might be several other classifications.

It was the sense of the committee that it would be the best plan to have all home signals of the electro-mechanical slotted or power type. That is, they should resume the "stop" position automatically after a train had passed them. But the idea of having all home signals thus is too idealistic, and is impracticable in some cases, due mainly to the excessive cost of installation and maintenance.

The electro-mechanical slot provides a cheap semi-automatic signal, and fulfills the requirements. As far as the actual operation is concerned, it is just as hard to operate as straight pipe-connected signals, but is somewhat more uncertain in responding to reverse movement of the lever. Its advantages over power operated signals appears to be that it is cheaper to install in most cases, and cheaper to maintain. It may possess another advantage; that is, in case of a failure of the electrical part of the slotted signal, the mechanical connection would assure its return to the stop position positively, whereas in the case of the power-operated signal there might be a chance for such electrical failures to cause false indications. The sentiment, therefore, was decidedly in favor of electro-mechanical slotted signals where practicable for drawbridges and grade crossing where two position signals are used.

Where signals are located on bridges, the cost of the slotted type is about the same as for the power operated. The slotted type of signal possesses a disadvantage in common with the direct pipe-connected type due to the fact that it cannot be located except at a more or less limited distance from the machine, and as it is quite common practice to locate home signals at a considerable distance from the tower, this type of signal could not always be used.

Power-operated signals, while at the present time somewhat higher in cost both in installation and maintenance, possess a number of advantages which, in many cases, outweigh the question of cost. In the first place it is extremely flexible. It may be located at any place, practically any distance from the machine, and is extremely easy to operate. A number of signals may be operated by one lever and the machine may be made considerably smaller than for the mechanical type.

The power type of signal possesses so many advantages, that particular attention is being given to it by all designers of signal apparatus, and there is no question but in a short time a signal will be evolved which will compare favorably in price with the mechanical types now in vogue. It is altogether likely that installations of this character will be made in the near future at even a lower cost than mechanically-operated signals, and the maintenance will no doubt be brought down in cost in proportion.

The slotted or power signals of whatever type, possess one feature in common, and that is the elimination of some of the human factor from the signal operation; this removes much of the responsibility from the towerman, and increases the efficiency of the plant.

*From the report of the Committee on Mechanical Interlocking, presented at the annual meeting of the Railway Signal Association, held at Louisville, Ky., Oct. 12 to 14.

Conclusions.

For the first class of interlocking plants noted above, the committee believes that home signals of the pipe-connected type will answer all requirements.

For the second class, all high-speed signals should be of the power type as it will be only a question of time before automatic signals are installed, and if of the three-position type, it would be much cheaper to employ power-operated signals than mechanical signals of the slotted type.

For the third class the direct pipe-connected signal will answer all requirements.

It must be understood, however, that each situation must be considered on its own merits, and the best arrangement determined.

The committee favors semi-automatic signals wherever high speed is the general rule, and power-operated signals in automatic signal territory with the following exceptions: The slotted mechanical pipe-connected signals at drawbridges, and at certain other points where they can be installed cheaper than the power type, and when local conditions werrant them; straight connected mechanical signals for governing yard movements, etc.

As a rule power-operated signals require that a competent man be kept at hand at all times to prevent delay to traffic, and therefore, your committee cannot consistently recommend this type of signal at points where traffic will not warrant going to this additional expense.

A DESTRUCTIVE WINDSTORM in Tennessee, Alabama, Arkansas and Georgia Oct. 14 caused heavy damage to property and the loss of 37 lives. The town of Denmark, Madison Co., Tenn., was reported entirely demolished.

During the hurricane at Key West, Fla., Oct. 11, the tug "Sybil" of the Florida East Coast Ry. was sunk and her crew of eleven men was drowned.

A REAR COLLISION on the Missouri, Kansas & Texas Ry., Oct. 12, near Greenville, Tex., resulted in the death of four men and the injury of several others. A freight train while standing on the main line taking water was struck by a following passenger train. The men killed were in the caboose of the freight.

A CLOUDBURST WRECKED A BRIDGE of the St. Louis & San Francisco R. R., over the Canadian River, four miles southwest of Fay, Okla., Oct. 8. Three 300-ft. spans were carried away by the flood. The total length of the bridge was 3,000 ft.

A BOILER EXPLOSION at the plant of the Griffin Saw Mill Co., near Eldorado, Ark., Oct. 18, killed seven persons and injured three others.

A DERAILED CAR WRECKED A BRIDGE at Richmond, Va., Oct. 6. A coal car was derailed in the yards of the American Locomotive Works beneath the Fifth St. viaduct connecting Richmond with Highland Park. The car struck one of the steel supports of the viaduct causing it to give way and bringing down one of the 75-ft. spans. With the exception of this one span, the bridge was not materially injured.

ACCIDENTS DURING CONSTRUCTION WORK on the national Transcontinental Ry. of Canada during the past year caused the death of 68 men and the injury of 22 others. Most of the fatalities were due to explosions of dynamite. More than 12,000 men were employed during the past year.

A PECULIAR ACCIDENT to a steam-turbine electric generating unit is reported by a correspondent in Lincoln, Neb. The shaft of a 750-KW., 2,300-volt unit, in the power-house of the Lincoln Traction Co., broke between the turbine and generator ends, allowing the heavy generator rotor to break through the casing. Bolts and small pieces of steel were hurled about the generator room and a few were driven several inches into the wall. There was little damage to other apparatus and no one was hurt though a track foreman, working outside the building, had his pants half torn off by a bolt that came through a window.

THE McCALL FERRY POWER CO., which is erecting a huge power plant on the Susquehanna River at McCall Ferry, Pa., and which has been in financial difficulties for some time, is to be sold under a foreclosure decree just issued by the United States Circuit Court. The date of the public sale has not yet been announced.

RAILWAY-CAR DESIGN CONTEST.—In Engineering News, Vol. 61, 1909, p. 484, mention was made of a competition for a design of electric car by the J. G. Brill Co., of Philadelphia. The contest centered briefly on competitive designs for electric-railway cars for city service and it was open to all seniors in all technical schools of the country. First prize has now been awarded to Mr. Charles T. Ripley, who graduated June, 1909, from the University of Illinois, railway-engineering course.

A LIFEBOAT CAPSIZED Oct. 13 in Lake Erie off Point Pelée, Ont., and six men were drowned. The boat was of steel with an air compartment at each end. It was overturned near the shore by a wave and only two of the eight men of its crew were able to regain the boat and cling to it until washed ashore. The boat was attempting to go ashore for assistance for the wreck of the wooden steamer "George Stone," of Cleveland, which had been driven upon a sand-bar by the storm. The ten men of the crew who remained in the wreck were rescued.

RAPID TUNNELING IN ROCK was done on the Roosevelt drainage tunnel, near Cripple Creek, Colo., during several months of the past year. In March, 1909, the north heading was advanced 436 ft., and in June 410 ft. A long-time average of 362 ft. per month was made. The tunnel is 6 x 10 ft. in section, and the figures given were made in Pike's Peak granite. Two drills were used in each heading, and the men worked 8-hr. shifts. The tunnel will be 16,700 ft. long. It should be completed in the latter part of 1910. A shaft was sunk to give two intermediate headings, and the south heading from the shaft joined the portal heading in June, 1909. (A. S. Pierce, Supt.)

A NOTABLE AEROPLANE FLIGHT was made with a Wright flyer by Count Lambert, of Paris, France, on Oct. 17. He sailed from Juniay across Paris, made a wide turn about the Eiffel Tower and returned to Juniay. The whole trip covered about 30 miles and was made in 50 minutes. Count Lambert kept his machine high all during the flight, seldom dropping below 500 ft., and reaching, at the Eiffel Tower, about 1,300 ft.

SURVEYS FOR AN OUTLET TO A HUDSON BAY port for the railways of northwestern Canada are to be made this winter. A party of engineers started out from Pas Mission on Oct. 18. The winter is more favorable than the summer for surveying operations in this region notwithstanding the severity of the climate. Supplies are preserved by the cold, traveling over the frozen swamps and streams is easy and the insect pests of the summer are absent.

REINFORCED-CONCRETE NOMENCLATURE and algebraic notation is to be standardized in Europe by a committee of the International Society for Testing Materials. In a preliminary report recently issued there is given a tentative list of letters to represent the various dimensions and forces used in theoretical analyses of beams and columns. For these letters the following system has been followed:

(1) Small Roman letters are to be used for measurements of length and for loads per unit length.

(2) Capital Roman letters are to be used for areas and for forces.

(3) Small Greek letters are to be used for coefficients and for stresses.

This system is, as a rule, followed in all foreign technical literature.

NEW YORK STATE BARGE CANAL WORK is progressing at a more rapid rate than heretofore, though the reports of the progress are somewhat delayed by the headquarters' office. The "Barge Canal Bulletin" for September, 1909, just issued, states that during August, 1909, the monthly cost of construction work for the first time passed a million dollars, $1,016,170 to be exact. The chief items that make up this work are an excavation of 1,500,000 cu. yds. and concrete laying to the amount of 63,000 cu. yds., each the largest monthly total since the beginning of the work.

Personals.

Mr. A. A. Allen, Vice-President and General Manager of the Missouri, Kansas & Texas Ry., has become President, succeeding Mr. A. H. Joline.

Mr. Daniel H. Deeter has been appointed General Master Mechanic of the Philadelphia & Reading Ry., with headquarters at Reading, Pa.

Mr. Edward J. Kunze, M. Am. Soc. M. E., of Newark, N. J., has been made an instructor in steam and gas engineering at the University of Wisconsin, Madison, Wis.

Mr. I. G. Rawn, Vice-President of the Illinois Central R. R., has become President of the Chicago, Indianapolis & Louisville, Ry., to succeed Mr. W. H. McDoel, resigned.

Mr. H. H. Stoek, recently appointed Professor of Mining Engineering at the University of Illinois, has been appointed a member of the Illinois State Mining Commission.

Mr. George D. Brooke has resigned his position as Superintendent of Motive Power and Machinery of the Isthmian Canal Commission and has sailed for the United States. He entered the service of the Commission Oct. 17, 1904.

Mr. Allan Purvis, Superintendent of the Canadian Pacific Ry. at Nelson, B. C., has been appointed Local Manager of the Fraser Valley branch of the British Columbia Electric Ry.

Mr. W. H. Cullers, who has been employed in the structural department of the Cambria Steel Co. for the past seven years, has become Chief Engineer for the Northwest Steel Co. in Portland, Ore.

Mr. R. F. Walters has been appointed Acting Supervising Engineer in the Reclamation Service to succeed Mr. Ira W. McConnell, M. Am. Soc. C. E., whose resignation was noted in our issue of Oct. 14.

Dr. Herbert D. Pease has resigned as Director of the State Hygienic Laboratory of New York and has become Director of the department of bacteriology of the Lederle laboratories, 39-41 West 38th St., New York City.

Mr. Geo. B. French has resigned as General Agent of the Chicago, Milwaukee & St. Paul Ry., at Chicago, Ill., to become President of the Spokane, Portland & Seattle Ry. He is expected to assume the duties of the new position Dec. 1.

Mr. R. E. McDonnell, M. Am. Soc. C. E., of Kansas City, Mo., has recently returned from a three months' trip in Europe during which he investigated the operation of sewage purification plants in Germany, France, England and Scotland.

Mr. Carl Weber, President of the Weber-Duller Co., engineers and contractors, Houston, Tex., has opened a new office of that company in Los Angeles, Cal. Mr. David M. Duller, General Manager of the company, will remain in charge of the Houston office.

Mr. Fred. Lavis, M. Am. Soc. C. E., formerly Resident Engineer of the Pennsylvania R. R. tunnels at New York City, has associated himself with the firm of Guerber, Lavis & Co., general and consulting civil, mechanical and electrical engineers of 50 Church St., New York City.

Mr. F. W. Scheidenhelm, who has been connected with the West Penn Rys. Co., of Connellsville, Pa., as Structural Engineer, has associated himself as Consulting Engineer, with Mr. James B. Hogg, Civil and Mining Engineer, with headquarters at Connellsville, Uniontown and Scottsdale, Pa.

Mr. Granbery Jackson, Assoc. M. Am. Soc. C. E., has become Chief Engineer of the International Agricultural Corporation, of New York City, with office at Nashville, Tenn. This recently organized corporation controls phosphate mines in Tennessee and Florida, potash mines in Germany, fertilizer plants in southern and eastern states and the sulphuric acid output of the copper mines at Ducktown, Tenn.

Mr. Fred. W. Honens, M. Am. Soc. C. E., U. S. Assistant Engineer, at Sterling, Ill., has been transferred from the work on the Illinois & Mississippi Canal (where he has been employed for a number of years) to the work on the Missouri River. He will have charge of the Missouri River above Omaha, as Assistant Engineer, and will have headquarters at the U. S. Engineer Office, Postal Telegraph Bldg., Kansas City, Mo.

Mr. W. D. Waltman, Assoc. M. Am. Soc. C. E., General Superintendent of the Isthmian Canal Commission's quarries and crusher plant at Porto Bello, Panama, who has been appointed Acting Resident Engineer of the Atlantic Division, in charge of procuring sand, stone and cement for the Gatun locks, has resigned that position to become engineer in charge of construction for the Costilla Estates Development Co., a large private land and irrigation corporation in Colorado, with headquarters in Colorado Springs. Mr. Waltman had been in the service of the Commission for five years.

Mr. Charles M. Hays, President of the Grand Trunk Pacific Ry. and Vice-President and General Manager of the Grand Trunk Ry., has been chosen to succeed Mr. C. R. Wilson as President of the Grand Trunk Ry. The change is to go into effect Jan. 1. The annual report states that "considering Sir Rivers-Wilson's great services a resolution will be submitted to the proprietors for a retiring allowance of £1,500 per year." Mr. Hays first entered railway service in 1873 as a clerk in the passenger department of the Atlantic & Pacific R. R., at St. Louis, Mo.

Mr. Everett E. Stone, M. Am. Soc. C. E., has resigned his position as Chief Engineer of the Boston & Albany R. R. to engage in private business in Springfield, Mass. He has been succeeded by Mr. F. B. Freeman, Engineer of Construction of the New York Central & Hudson River R. R. Mr. Freeman's office will be at South Station, Boston, Mass. Mr. Stone had been in the employ of the Boston & Albany R. R. since 1887, serving successively as a surveyor, Assistant Roadmaster, Division Roadmaster, Assistant Chief Engineer, Engineer of Maintenance of Way and Construction, and Chief Engineer. He had occupied the last-named position for two years. While he was Assistant Chief Engineer he was twice elected Mayor of Springfield, Mass. Mr. Julius W. Pfau, Assoc. M. Am. Soc. C. E., formerly Engineer of grade crossing elimination for the New York Central, has been appointed Engineer of Construction to succeed Mr. Freeman.

Obituary.

George D. Fowle, Consulting Signal Engineer of the Pennsylvania R. R., died Oct. 14 at the Rittenhouse Club, Philadelphia, Pa. Mr. Fowle was born at Alexandria, Va., in 1860.

Frederick C. Bieg, Commander, U. S. N., died Oct. 14 at the Naval Medical School Hospital, Washington, D. C. He was Fleet Engineer of the North Atlantic fleet and also Engineer Officer of the battleship "Maine" from April, 1905, to March 1906, and was afterward assigned to duty in the Bureau of Steam Engineering.

Robert W. Milligan, Rear-Admiral, U. S. N., retired, died Oct. 14 at his home in Annapolis, Md., aged 66 years. Admiral Milligan was Chief Engineer Officer of the battleship "Oregon" at the time of its record-making trip from the Pacific coast to the Atlantic during the Spanish-American War. In July, 1899, he was placed in charge of the Norfolk Navy Yard as Chief Engineer Officer and served in that capacity up to the time of his retirement in April, 1903.

Smith S. Leach, Col., Corps of Engineers, U. S. A., died Oct. 16 at the Emergency Hospital, Washington, D. C., from an attack of uremia. Col. Leach was born in Indiana in 1851 and graduated at West Point in 1875 During his service in the Corps of Engineers, he has taken an active part in the river and harbor work in Long Island Sound, Lake Champlain and the St. Lawrence, Missouri and Mississippi rivers. Col. Leach would without doubt have been promoted to the position of Chief of Engineers had it not been for his prolonged ill-health.

Charles Sewall Gowen, M. Am. Soc. C. E., died Oct. 19, at his home in Ossining, N. Y. His death followed an accident which he suffered two days before when he fell while walking about his room and broke his thigh. He had been suffering from rheumatic gout for several months. Mr. Gowen was educated at the Massachusetts Institute of Technology. For twelve years he had charge of the construction of the Cornell dam, a part of the water supply system of New York City. Upon the completion of the dam, he resigned from the city's service and has practiced since that time as a consulting engineer.

Engineering Societies.

COMING MEETINGS.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 28-30. Annual meeting at New York City. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Nov. 9-11. Annual convention at Little Rock, Ark. Secy., A. P. Folwell, 239 West 39th St., New York City.

NATIONAL MUNICIPAL LEAGUE.
Nov. 15-19. Annual meeting at Cincinnati, Ohio. Secy., Clinton R. Woodruff, Philadelphia, Pa.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 16. Annual meeting at Washington, D. C. Secy., Martin S. Decker, Albany, N. Y.

AMERICAN RAILWAY ASSOCIATION.
Nov. 17. Annual meeting at Chicago, Ill. Secy., W. F. Allen, 24 Park Place, N. Y.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 18-19. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 1-3. Annual convention at Milwaukee, Wis. Secy., James C. Monaghan, 20 West 44th St., New York City.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 3-4. Annual meeting at Laurel-in-the-Pines, Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 6. Annual meeting in New York City. Secy., Wm. H. Ross, 154 Nassau St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 7-10. Annual meeting at New York City. Secy., C. W. Rice, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 8-10. Annual meeting at Philadelphia, Pa. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 14-15. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 14-16. Annual convention at Washington, D. C. Secy., Glenn Brown, The Octagon, Washington, D. C.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27. Annual meeting at Boston, Mass. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 28-29. Annual meeting at Ames, Iowa. Secy., L. W. Chase, University of Nebraska, Lincoln, Neb.

AMERICAN ROAD MAKERS' ASSOCIATION.—The sixth annual convention will be held at Columbus, Ohio, Oct. 26-29. Mr. E. L. Powers, 150 Nassau St., New York City, is secretary.

NATIONAL CIVIC FEDERATION.—The tenth annual meeting will be held Nov. 22-23 in New York City. The main subject to be considered will be that of industrial insurance, including sick and death funds for employees, compensation for accidents, employers' liability and old-age pensions. Members of the several state commissions now at work on this problem will be present. The offices of the federation have been moved to Rooms 10002-10108 Metropolitan Bldg., New York City. Mr. D. L. Cease is secretary.

AMERICAN ELECTROCHEMICAL SOCIETY.—Papers to be presented at the annual meeting in New York City Oct. 28-30, are announced as follows: Oct. 28, "The Titanium Arc," W. S. Weedon; "The Element Boron," H. Weintraub; "A New Electrolytic Method for the Preparation of Explosive Antimony," R. C. Palmer. Oct. 30, "The Preparation of Silundum," S. A. Tucker, H. F. Kudlich and E. M. Heumann; "The Laws of Electrode Losses in Electric Furnaces" and "A New Method of Measuring Mean Thermal and Electrical Conductivities of Electrodes," Carl Hering; "Furnace Electrode Losses," C. A. Hansen; "Electrode Losses and Furnace Efficiency," E. F. Roeber; "The Practical Conductance of Electrolytes," Jos. W. Richards and W. S. Landis; "A New Theory of Corrosion," Maximilian Toch; "Evolution and Present Status of the Dry Cell," J. W. Brown; "Dry Cell Tests," F. H. Loveridge; "Some Characteristics of Dry Cells," C. F. Burgess and Carl Hambuechen; "Manufacture of Air-Saltpeter by the Process of the Badische Anilin and Soda Fabrik," C. Schönherr; "Power for Electrolytic Copper Refining at the Buffalo Smelting Works," W. L. Spalding.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The paper on the high-pressure fire-service pumps of New York City, which was published in Engineering News Oct. 7, was presented by Professor R. C. Carpenter at the meeting of Oct. 12. There was a large attendance and more than the usual interest was taken in the paper and the discussion that followed. A brief description of the electrical features of the high-pressure system was given by Professor Geo. F. Sever, of Columbia University. He called particular attention to the penalty charge of $500 per minute which the New York Edison Co. must pay for any interruption of current in excess of three minutes.

The chief subject of discussion, introduced by Mr. Wm. M. White, Hydraulic Engineer of the I. P. Morris Co., Philadelphia, Pa., concerned the explanation of the greater efficiency obtained in the case of the test of individual pumps delivering water into the main singly than when the same pumps were operated together delivering water into a single main. The difference in efficiencies amounted to from 4% to 6% and is ascribed in Professor Carpenter's paper to "less loss in eddy currents and friction head, etc.," for a single pump operated alone, and the paper states that this difference is believed to generally exist in centrifugal pumps under similar conditions.

Mr. White desired to know just where the eddy currents and friction head occurred and why they should be more pronounced when the pumps were operated together. His experience did not support the statement that the above difference in efficiences generally existed. There was considerable further discussion along this line but no satisfactory definite explanation was brought out. Mr. White later in the evening presented lantern slides of curves plotted from tests of centrifugal pumps showing efficiencies of from 79% to 82%.

Mr. G. L. Fowler, of New York City, described the deepening of the channel leading into New York harbor by means of hydraulic dredging with centrifugal pumps. Mr. John H. Norris, Assistant Engineer of the National Meter Co., Brooklyn, N. Y., described the high-pressure system of Coney Island, where triplex reciprocating pumps are driven by gas engines and deliver 4,500 gals. per minute at 150 lbs. per sq. in. Mr. Thomas J. Bannon and Mr. Henry B. Machon, Assistant Engineers of the department of water supply, gas and electricity of New York City, gave details of results obtained in the operation of the high-pressure system.

Others who contributed to the discussion were J. R. Bibbins, Public Service Commission, New York; J. J. Brown, Mechanical Engineer, Wheeler Condenser & Engineering Co., Carteret, N. J.; Geo. A. Orrok, Mechanical Engineer, New York Edison Co.; Frederick Ray, Chief Engineer, Alberger Pump Co., New York City; H. Y. Haden, President Turbine Equipment Co., New York City.

It was announced by the secretary, Mr. Calvin W. Rice, that a joint meeting will be held with the Institution of Mechanical Engineers in Great Britain July 26-29, 1910. At the meeting of Nov. 9 in New York City a paper will be presented on reinforced-concrete beams by Professor Gaetano Lanza and Mr. Lawrence S. Smith, of the Massachusetts Institute of Technology and a paper on "Stresses in Curved Machine Members" by Professor Walter Rautenstrauch, of Columbia University. The paper on reinforced-concrete beams is the same presented at the Boston meeting of Oct. 20.

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